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REVD. JOSEPH SUTCLIFFE, A.M.

THE

GEOLOGY OF THE AVON,

BEING AN

Enquiry into the Order of the Strata

AND

MINERAL PRODUCTIONS

OF THE

DISTRICT WASHED BY ITS STREAMS.

By JOSEPH SUTCLIFFE, A. M.

Et vomit oceanus pontum, sitiensque resorbet,
Nec sese ipse capit, sic quondam merserat urbes,
Humani generis quum solus constitit hæres
Deucalion. MANILIUS ASTRON. LIB. IV, 830.

* * * * The ocean wide
Throws up the sea, and then resorbs the tide;
Nor would it thus forbear the angry play,
Till the Alps were bar'd, and cities wash'd away;
Deucalion only then obtained the grace
To be the Sire of all the human race.

Bristol:
PRINTED BY PHILIP ROSE, BROADMEAD;
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1822.

18851. d. 2.

THE
GEOLOGY OF THE AVON.

DERHAM, RAY, and many others, have rendered important services to the cause of truth by tracing the wisdom and goodness of God in the creation and preservation of the world. I am wishful to tread in the same road, and guard the cause of truth against the peculiar attacks to which it is tacitly or openly exposed in the present age. During the last fifty years, those studies have been largely resumed in Europe and America, as also by many in Asia. Men of talents, of travel, and of strong understandings, have come forward to augment the stores of public knowledge, and have favoured us with the most exact and scientific examination of every mineral. The vast extent of mining, and the luminous discoveries of modern chemistry, have lent their aid, and alike united practical and scientific men in these researches. While innumerable things have been discovered which amuse and gratify the mind, others have been hit upon of real benefit to society.

Geognosy, or a knowledge of the earth in the nature and relations of its strata, has an equal tendency to moralize the heart, and to improve the mind. While the student everywhere perceives the consummate wisdom of the Creator in the formation of all his work, and in the proportion and arrangement of the whole, how can he bear to see irregularities in his own heart, and improprieties in his character.

And it is of greater consequence to remark, that these studies can in no sense whatever be unfavourable to the christian revelation: all efforts to the contrary, proceeding from unbelieving circles, are found to be the mere results of presumptive theories. How can the study of nature which provides no remedy of an efficient nature for the moral miseries of man, ever prompt the student to revolt against a religion which is consummate in its doctrine, and perfect with regard to the radiance of an immortal hope? In the kingdom of nature we do find a remedy for most diseases incident to the body, and is it likely, rising on the scale of Divine beneficence, that there should be no remedy provided by the all gracious Being for the more tender and poignant diseases of the heart? We may be assured that this Being has not left his works of grace in a limitted and imperfect state, while all his other works are demonstrated to be complete.

In the pursuit of geological studies, one of the chief difficulties arises from the wide discordance of modern theories: and variations so considerable, are certain indications of the imperfect state of our knowledge, and the fallacy of our deductions.

One system, now called the Plutonian, regards, the earth's crust on which we now live, as the debris of two former worlds, and our present continents as the elevations of the bottom of the sea by subterranean heat. If this theory be founded on fact, why do not our rocks present us with beds of shell-fish in families as now living at the bottom of the sea? Why do they, on the contrary, every where exhibit millions of testaceous animals, coralites, zoophites, &c; thrown in the utmost state of confusion, as the wreck of impetuous waters, whose flux and reflux were long continued on the earth? This theory has been wholly founded on a mistake of the great heat which followed the deluge in most of the flood-formed mountains for volcanic effects. In the Whin and Basaltic neighbourhoods, we find the coal and the graphites actually charred; we find stones which have on one side a slight appearance of fusion, while the laminae of the crystals remain undisturbed; in other places we find asphaltic and bituminous masses distilled by heat from the superincumbent vegetable strata. Humboldt, on contemplating the dazzling elevations of nature on the Pike of Teneriff, emancipated himself from this mistake. "When the Canary Islands," he says, "shall have been some day examined in all the parts which compose the system of those mountains, we shall find that we have been too precipitate in considering the whole group as raised by the action of submarine fires."

Another theory, denominated the Neptunian, and adopted by all the classes of the Wernerian geologists, maintains, that the earth's surface was for a considerable time covered by an universal water from which has proceeded all the transition or secondary orders of rocks; all metallic veins are said also to be rents filled up by the depositions of those waters; and that the alluvium in all places has proceeded from later depositions of water.— This system, as yet confessedly unsettled, has not emancipated itself from an error which obtained in the Hebrew schools, and is generally followed by the fathers of the primitive church in their comments on the text of Moses, who is made to say in the English version, that "all the fountains of the great deep were broken up; and the windows of heaven were opened; and the rain was upon the earth forty days and forty nights." *Gen.* vii. 11, 12. If such a sheet of water really did increase upon the earth for one hundred and fifty days, and was a hundred and twenty in retiring, one of our most industrious Wernerians is justified in asking, "What has become of the immense volume of water that once covered and stood so high upon the earth?" *System of Mineralogy, vol.* iii, *page* 82. *ed.* 1808.

Certainly Moses never names any such volume of water; and windows both here, and 2 *Kings*, vii. 19, is a mere figure, of speech, not a translation. The reading of the Septuagint which is followed by the Vulgate, is, "And the cataracts of heaven were opened." וארבת השמים נפתחו: *ϰαι ὂι ϰαταῤῥαϰται τοῦ οὐρανου ἠνεώχδησαν.* *Ed. Cantab.* Et cataractæ cæli apertæ sunt.—*Ed. Vulgat.* Now, a cataract is defined by *Roubaud*, the learned author of the French *Synonimes*, to be—"a broken falling stream." Those cataracts could then be no other than the recoil of the mighty seas, washing those deep bays mentioned in the introduction, *page* 25. Moses wrote cataracts, not windows; the rain, the darkness, and the thunders seem to be named as the terrific concomitants of those reversions of the laws of nature. With these ideas, that attentive student of nature, the late

Rev. A. S. Catcott, B. D. of Bristol, has versified the passage in the 104th Psalm.

"At thy command the affrighted waters fled,
And sought tumultuous their appointed bed;
O'er hills they roll'd, and follow'd the descent;
Deep channels tore, and the split vallies rent."

Mr. Merrick has the same idea; for those vast volumes of water had no retreat but in the tremendous reflux of the tides.

"He spake, and o'er each mountain's head,
The deep its wat'ry mantle spread;
And first adown their bending side,
With refluent stream the currents glide."

Manilius, as on the title-page, who, no doubt had studied geology on the Alps, and who dedicated his poem on astronomy to Augustus, fully embraced the idea of the desolations of the earth by the flux and reflux of tremendous tides. This deluge, according to Moses, lasted two hundred and seventy days, which period twice comprises the high tides of the equinox. The idea of two equinoctial courses of tides, seems to relieve geology of very many difficulties under which it has hitherto groaned. Because what are called transition rocks by a certain class of writers on the Continent, and which some christian writers, captivated by the novelties of theories, have too precipitately copied, are no other than the rocks formed by the powerful tides of the first equinox. These tides were quite adequate to wash up new mountain ridges, and lay on hills in the calmer places of the flood-washed hills. Masses so large, depositions so heterogeneous, must instantly proceed to the fullest exertions of their chemical energies. The consequent heat would be very considerable, but varied in proportion to the composition of the deposits. The subtle fluids; I would say, the inscrutable essences of all minerals, would unite by affinities, the metallic veins would form first, being of superior strength; the crystallizing power of the alkalines would form the rocks; yes assuredly, and in the course of a few days, as is demonstrated by the speedy shooting of crystals in every chemical process. And the daily tides, laying on new matter, which would break into strata, some of thirty or forty feet in thickness, and others of two, three, or four feet, would continue to be seized by the mysterious, but predominant fluids, and continue the sports and formations through the whole kingdom of the new alluvial earth, as had been the case in the first creation.

Dr. John Lightfoot, in his commentary on the seventh of Genesis, has corrected an error into which many writers fall by mistaking the Hebrew ecclesiastical for the civil year: the former commenced on leaving Egypt, whereas the civil year began in the middle of our September by the month of *Tisri*. The Doctor has given us a regular calendar of the forty days of rain, the hundred and fifty days in which the waters increased, and the hundred and twenty in which they ebbed! The Doctor further notices the time of Noah's entering into the Ark as a designation of the divine wisdom: it was after the harvest was saved, and the fruits gathered, which just allowed the patriarch time to victual the Ark.

The lower deck of this most extraordinary *batiment*, the Dr. gives as containing 450,000 square cubits, and the timbers he describes as terminating in the air at one cubit, giving the Ark the figure of a roof, while the lower holds drew fifteen cubits of water. *See Introd.* p. 22, 23, 24.

This account of the deluge by no means rests on the single authority of Moses: it is the tradition of the whole ancient world. "Hast thou," said Eliphaz to Job, "marked the way which wicked men have trodden? Who were cut down out of time, whose foundation was overflown with a flood, who said to God, depart from us; and what is it that the Almighty can do? Eusebius, in his Preparation of the Gospel, gives us a list of authorities on this subject; among these are Berosus, historian of the Chaldeans; Abdenus, Plato, Africanus, &c. The Chinese, the Hindus, the Mexicans, have all similar traditions of this catastrophe. The Mexicans, according to the Spanish historians, have a tradition, that four men saved themselves on their high mountains which seems no other than Noah, and his three sons. But were it true, that any animals survived, either on the mountains of Mexico, which are one fourth higher than the Alps, or on the ridge of Thibet, whose highest summit is given by Col. Kirkpatrick as 26,462 feet high; it could not affect the truth of the Mosaic History, as those regions were then unknown. Those ridges during the deluge could not be covered with snow, as the elevation of the waters would alter the temperature of the atmosphere.

Presuming, therefore, that as the first strokes of the deluge followed the high tides of the autumnal equinox, the testaceous fish attached to rocks near the coasts, would be among the first depositions of the deluge, we may on this principle account for the paucity of recent shells as being more deeply entombed than others. Shells, lying deeper and more remote in the bosom of the ocean, must be among the latter depositions of the tides. As every climate of the earth is distinguished by an appropriate variety of animals and of plants, and as all the high mountains have their succession of climates containing different orders of plants, so it would seem to be the case with the sea, whose depths are supposed to correspond to the elevation of the continents. Conformably to these ideas are the discoveries of geological travellers: while they find on all coasts and continents, some which are common to other countries, they find also inexhaustible varieties of organic petrifactions unknown to the students of nature.

The productions gathered in the district washed by the streams of the Avon are in perfect unison with these attestations. The genera beggars our terms, and the species would require a catalogue. Among these, the Ammonites, myriads of which are deposited in the shaly lias on both sides of the river, obviously inhabitants of the deeper seas, as being provided with cellular cavities for the retention of air, are nearly all fractured with the long journey on a rugged coast over which they have been impelled. Among a thousand, I have seen but two which were perfect, having the expanse at the termination of the coil to give the animal liberty in its adherence to the rocks. The shell in one instance was thin, and transparent, and the expanse guarded by a double thickness of the shell in form of a collar.

When I consider the multifarious depositions of organic remains in the whole district of the Avon, remains of animals once hostile to each other, but now peaceably entombed in the same strata, how can one be prepared to receive the assertions of modern Geology, that, "*the miner finds a new world of organic remains in every new order of strata to which he descends; and that each order belonged to some former world before the existence of the human species!!*' Of course, we are compelled by facts to regard such theories as the ebullitions of the fancy, during the yet juvenile state of the science. If these remains are found in the lowest recesses of coalfields; if Humboldt found them at the elevation of 14,000 feet on the Andes, is there any theory so satisfactory in the present state of our limited knowledge, as the flux and reflux of impetuous waters for eight or nine months on the earth? If the currents of the Atlantic are so gentle as not to throw a ship more than one or two degrees out of her reckoning, how could a mere elevation of a volume of water, two or three miles above the level of our vallies, produce effects in all places so extraordinary?

The geological relations of the Avon have for their base a vast granitic range which appears on the coast of Brittany, and the Norman isles, rises on the broad extent from Dartmoor in Devon to the isles of Scilly, re-appears in Anglesey, and the sharply defined summits of Malvern Hills, extending to Cumberland, and the high summits of the Scottish hills and isles. A branch from the above range crops out at Mount Sorrel of a dull red, not unlike what I have seen in Jersey. Kellas or shale, clays and other primitive formations, destitute of all organic remains, are known to accompany these ranges. The late Rev. Mr. Catcott, an exact observer of nature, has delivered an opinion, that we are at no great distance from the primitive rocks. (see p. 70.) The roof-shaped position of the coal-strata, as well here as in Staffordshire, is a sure indication of the correctness of this idea. And unless we admit this conjecture, how can we account for the formation of many of the bolder hills with round summits, as at Warminster, Brent, Marksbury, and on Salisbury Plain? There must have been a base to resist the currents, and protect the depositions. Unless we admit this conjecture, how can we account for the huge rocks of beautiful white sandstone of Stonehenge, and some adjacent places? We have no such sandstone in England as the four varieties found there. The late venerable De Luc has delivered an opinion, that all such rocks have fallen from more elevated situations. Thus the deluge, while it desolated the mountain-ridges, seems to have enlarged the plains, and increased the rich pasturage of the future surface. In the geological relations of the Avon with regard to the flood-washed hills and vallies, one circumstance is very apparent, that the majestic stream of the Severn, during the overwhelming flux and reflux of the sea, has so far preserved an influence, that the same formations have been effectuated on the right and left bank of the river. The marmor, often called mountain limestone, the shaly lias, the coalfields, and the red sandstone on both the shores have a striking coincidence of character. But the balance in regard of the thickness of the coal, and the richness of the iron ores, is highly in favour of Wales.

In tracing the general geological relations of the flood-formed hills and plains, the want of knowledge is a difficulty with which all researches are circumscribed. The well-sinkers no where penetrate beyond the beds of beach-worn gravel, in which they are sure to find abundant supplies of water. This gravel occurs in the alluvium of the Avon between High-street and Redcliff-hill in Bristol, at the depth of forty feet, covered with a vein of indurated clay, through which the water of the cream-coloured superincumbent quicksand cannot penetrate. It occurs under the marble of this district, as under the chalk of Hampshire, and the alluvium of Cheshire. (*see page* 44, 69.) The millgrit rocks, with interruptions, extend from the Severn to the south of Frome, and correspondent formations of it occur in Wales. Above this is seen, at the termination of the hauling path on the Leigh side of the Avon, the soft red sandstone, making horizontal shoots through Bristol, and the vicinity, which may be regarded as a formation in the red ground of the country, and as having many distinctive characters from the old red sandstone of Stapleton. Then follow the marmorous ranges, which form the hills of this neighbourhood, and have the closest affinity to the Devonshire marbles, as appears from twenty specimens which Mr. Hay had cut and polished. The old red sandstone next appears above the coal, east of Bristol, having a similarity of colour and formation to that of Devonshire, Staffordshire, and the north. The microscope does not present any difference between specimens collected at Liverpool and Stapleton. Proceeding eastward, the rising grounds and hills present us with the shaly lias; and as we approach to Bath immediately this lias is succeeded by the ōōlite, which seems to deteriorate to the east, and lose itself under the bolder risings of the chalk formations of Calne, Westbury, and Lavington. These ōōlites take a wide but narrow spread, rising at Portland, and extending through the Gloucestershire hills, and the rising grounds of Oxfordshire, terminate at Thorp Arch, and in the vale beyond Pickering in Yorkshire. The chalk formations have a spread correspondent to those of the marble and mountain limestone ranges. They reach from this district to the Yorkshire wolds, on one side, and the vicinity of Paris, on the other, re-appearing in the island of Gotland beyond Copenhagen. The strata of the eastern counties cover the chalk, and consequently were among the later depositions of the deluge. What strata, what metallic veins, and mineral treasures those counties may contain, cannot be known till pits are sunk to greater depths than any of the present wells.

The local relations of the Avon have been visited in the south by Leonard Horner, Esq. "The four hills," he says, "Quantock, Grabbist, Croydon, Brendon, (and others in the west of Somerset) consist chiefly of greywacké: but Quantock is traversed with a vein of limestone. The greywacké is called by the workmen dunstone and shillat. In the north-western district of Somerset, large proportions of the rocks have a sandstone structure, whose component parts are very fine. Quartz in some of those rocks so far prevails as entirely to exclude the other ingredients. The prevailing colours are a reddish brown, and a greenish grey; but with many intermediate mixtures of colour. No trace of organic remains was found in any of the varieties of sandstone; but beds of limestone occur full of madrepores. Veins of quartz, which are often of great magnitude, are of constant occurrence, being sometimes accompanied with calcareous spar and ferriferous carbonate of lime. Veins of sulphate of barytes are not uncommon. Thin layers, composed of quartz and chlorite, are often interposed. Copper, in a state of sulphuret, and of malachite, and veins of hematite, are frequent. Nests also of copper ore of considerable magnitude have occurred in subordinate limestone." *Geol. Trans.* vol. iii, p. 340—354. The reader would be gratified by seeing the paper at large.

The first great strokes of the deluge would desolate the primitive hills, excavate new vallies, and even remove the shores of our present seas. And the rolling of an ocean which washed the Alps would equally wash the bottom of the sea. But where the primitive ridges and hills formed resistance, depositions would be made equal to the erotions of the waters. Hence there is not the least need of the theory, that our present continents rose from the bottom of the sea, because the bottoms of the sea being eroted, were deposited on the hills.

The coalfields of this and other districts, must, it would seem, have been among the earlier depositions of the waters, for the flotillas of timber, with marine and terrestrial vegetables, being locked fast by the roots and branches, would be left behind on the declivities descending from the hills to the deepest vallies; for as Mr. Williams justly observes, the beds of coal never go through the hills, but are always inclined. Vegetable depositions, locked so fast, and always inclined, would be entombed by the turbid matter of the next tide, before the sea could be sufficiently advanced to raise the flotilla of the preceding tide. It is the superabundance of fern and other vegetables, often mixed with marine productions, which prompts the idea of the deeper coalfields being among the earlier depositions of the deluge. When I have had before my eyes the lithophytes or vegetable impressions found in the harder Dunstone of our pits, with the muscles found just above the coal at Middleton near Leeds, I have softly said, "These little creatures are now become so strong as to dash in pieces certain theories of modern geology at a single stroke."

Taking it then as a principle the most assured, that the primitive rocks are at no great distance from the deeper strata to which our miners have penetrated, as is indicated by the coal which in some places diminishes its dip, and by the configuration of our mountain-ridges and conic-hills, we may commence our local inquiries with the coalfields, and rise as a building from its foundation.

The coalfields watered by the Avon, extend from the vicinity of Bristol, to the south and south-east for the space of thirty miles. The beds are few and thin compared to those of Wales, Warwickshire, Staffordshire, Yorkshire, and Newcastle; yet they are not thinner than those of the county of Durham, where twenty-five have been counted dipping, eastward from Crossfel to the sea. Here the pits never penetrate through more than three or four veins. But though the miner cannot realize a princely fortune, as in other districts, no country can be more interesting to the student with regard to organic remains, and to the variety and structure of its rocks and ores.

The general dip of the coal is uniformly determined by the directions of the latent ridges, and the particular and local dip of all such strata is dependent on the directions taken by the branches of such hills: so that no subject in Geology can be more variable than the dip of the strata. All this is exemplified in the ridges and vallies of the Avon. A ridge runs from Bristol towards the Gloucestershire hills, which determines the dip of the lower strata of coal at Stapleton, and the lower strata at Kingswood, like the roof of a house. The Cockpit coal dips fifty or sixty degrees towards the north-west, and determines the dip of the superincumbent strata. The old red sandstone there has a dip of fifty-five degrees, while the same rock across the brook at Frenchay, as also at Stapleton, dips only five or ten degrees towards the east.

Being very much dependant on practical men for what I am going to write, whose terms at first I found it difficult to understand, though I saw many of the rocks and shales which they distinguished by local names, I cannot, of course, be responsible for the correctness of every expression.

The Cockpit is sunk through two fathoms of red ground. Then it obliquely penetrates the red sandstone for forty fathoms, comprised in various beds. The real thickness of this rock does not exceed twenty fathoms, but dipping at the great angle of fifty-five degrees, the sinkers have to work their way through the forty fathoms. A clam of soft argillaceous shale is next penetrated for three fathoms, under which the cock-bed of coal occurs, which is three feet thick. One or two feet under this bed of coal are veins of iron ore, formed in argillaceous shale. Under the Iron vein is a dun or shale for sixteen fathoms. Some of this dun is of a beautiful light blue, which, after considerable resistance, yields to the solvent action of the air, falling into quadrangular fragments. Two or three fathoms of hard greys (French grès) then occur: then a shaly sandstone used for flagging the poorer streets, as it abounds at the distance of every two or three inches with silecious nodules, about the size of one's little finger end, and which leave indentations on the opposite side of the flags. I have seen similar formations in the flag-stone of Ealland Edge, in Yorkshire, which is there denominated the pockey-lift or bed. Under these greys lies a red dun, or rather shale, for fourteen fathoms, which is so soft as to require the support of timbers to keep it from falling in. Below this a graphite occurs, which they use for writing on a slate, with other dunstone shales, till the sinker arrives at the main vein of coal, which is three feet and a half thick. The vein is there at the depth of a hundred fathoms, superincumbent on a hard dun; but dipping in so bold a manner, it must rise to the red ground or turf at no great distance. The miners follow it to a far greater depth than where it is penetrated by the pit. In this manner, the deluge has very kindly left a treasure of many other veins of coal on the Downend side, as a provision of comfort for posterity.

Passing over the subterranean ridge to the Kingswood successions of beds of coal, we find them all dipping the opposite way at the angle of forty five degrees or less in some places, to the south, south east, giving the clearest indication of a latent ridge which divides the vallies. Ridges of this kind are of common occurrence in the coalfields. The Burslem ridge extending to Mowcop, divides the dip of the Kidgrove and the Newton coal. At Bilston also a ridge occurs which determines the dip of the coal toward the north and toward the south. One of the best veins now worked lies on the declivity near the old school founded by Mr. Wesley, and is four feet thick. The present pits descend about sixty fathoms; but, of course, the former pits descending to the same vein were not so deep. Above this bed are veins, and reniformed nodules, of iron ores, having smaller veins above, as the Wichfield ores described page 31. A thin vein of brilliant glance shale occurs about a foot above the coal, which burns to white ashes.

On crossing the Avon to the Newton pits near the Globe-Inn, three miles west of Bath, we find a reversion of the dip in conformity to the ridge extending from Marksbury to Coomb Down. The pit nearest the river descends to the depth of eighty-four fathoms, penetrates a black vein of coal at the depth of fifty-four fathoms, which is only fourteen inches thick. Six fathoms below they find the coke vein; and penetrating twenty four fathoms more through a shale and then a strong rock of greys, they find the main bed of coal immediately under the grey or red sandstone rock. Veins of iron ore occur in the strata, as appears from detached nodules seen on the pit-hill; but their geological situations have not been noticed.

The pits on the Clutton ridge vary in depth according to the elevation or depression of the hills. The red ground in some places is there thirty fathoms deep, and in others but ten. The superior formations in this ground are the shaly white lias; and below that occurs a reddish sandstone, of which the church and the houses are built. The underlye of the sandstone is the millgrit. A cleaves or shale, often striped with the yellow oxides of iron, and largely so with blue or red, follows the Millgrit. This, as all other sulphurous shale, quickly decomposes on exposure to the air. But some parts of this shale are so hard that the men form them into hones for razors, and other thin parts are so indurated as to approach the characters of ardesia or roof-slate: in these are usually found beautiful impressions of fern. It was in the like shale at Coleford, that Dr. Woodward found impressions of the female fern, cinquefoil, clovergrass, and strawberries. *See Ray's Three Discourses*, page 125. Fish likewise occur in these harder shales, very much oblated with pressure, and whose scales have a protuberance regularly disposed in the proportion of four to an inch, and each protuberance has a slight cavity. Mr. Catcott mentions the vegetable impressions as occurring in some pits in an indurated clay, six feet above the coal; but does not name the place. Under the above shale is a bed of coal not exceeding four inches thick. Then immediately follow the various beds of greys, or sandstones, the best of which is sent to flag the walking paths of Bristol and Bath. In the fissures of these rocks the streams of water collect, and often so copious as to drown out the miner; for immediately under the greys is a vein of *lism*, or clay, so indurated that the waters cannot penetrate it. Ten fathoms below, the lism consist of cliff; immediately under which, at the great depth of one hundred and eighty-four fathoms, is the main bed of coal, not exceeding thirty inches in thickness. Four fathoms lower, after cutting through two beds of cliff and greys, is the third vein of coal; and twenty-four fathoms lower, of cliff and greys, is the fourth vein, having the greys for its roof. The dip is twenty-five degrees toward the south by east.

To the south-east of Clutton lies the range of coalfields, extending from Radstock to Clan Down. In the middle of this is the Welton pit, near Midsummer Norton. The pit descends through the red ground containing shaly limestone, in which petrifactions abound, and through the like order of millgrit, shale, and sandstone to the depth of two hundred fathoms, where the main bed of coal occurs, which has a diminution of dip to eighteen degrees. I take this diminution, which is somewhat greater at Nailsea, to indicate an approach to the lowest part of the vallies eroted by the diluvian tides.

The Sutton coalfields extend from two to four miles west of Clutton. The pit of the old colliery descends through sixteen fathoms of red ground, which contains a thin rock of red sandstone. The shaly limestone is adjacent, but here the situation cuts it off. The hard millgrit is then penetrated for three or four fathoms. The cleaves or shale for one fathom. The greys, which are here a continuation of hard shelving sandstones, divided by thin beds of clay, extend for ten fathoms. The cliff or hard shale next occupies a position for forty fathoms. In the harder parts many vegetable impressions occur. Under the above cliff lies a bed of glance or shining shale coal, which is only fourteen inches thick. Cliff occurs again for three fathoms, and is the immediate overlye of the main vein of coal, which like that of Clutton is only thirty inches thick. Below this vein, cliffs or graphites occupy a position of twelve fathoms, and are the superincumbent strata of the third vein of coal, which is sixteen inches thick, and reposes on a pan vein of indurated clay, which is five inches thick. I could not procure any of this pan vein; but the darkness of its colour excited an idea, that as the stone coal, extending with interruptions from Tong to Wakefield in Yorkshire, lies immediately under a thick vein of that district, and receives much of its strength, no doubt, from the turpentine distilled from the superior coal, there might here have been the like formation, had the bed been as thick as the beds where the like cannele coal is formed. Instead of stone coal, we have here a mere drub or slate in the coalpit glance. Below this pan vein, cliff and grey rocks in thin beds occur for eight fathoms. Then is found the fourth bed of smith's coal, so called because it is fit for the forge.' It was probably a deposition of marine vegetables. There is indeed a vein of coal ten fathoms below the smith's vein, and at the distance of ninety-six fathoms from the surface, but it is not worked. The dip of the main coal here, as at Clutton, is from twenty-five to thirty fathoms, taking a direction of south by east. Lithophytes are found here, but only in the harder shale, the sulphuric acid having decomposed them in all the softer cleaves and duns.

The pits west of Pensford are dug no lower than twenty fathoms, where are two thin veins of coal from fourteen to sixteen inches thick, divided from each other by a stratum of three fathoms. Immediately under the lower coal, are nodules of lead, weighing from one to eight pounds.

The Bedminster, or rather the upper Ashton pit, descends to the depth of one hundred and twenty-seven fathoms. The pits nearer the brooks are not so deep. The first vein of coal is about three feet and a half thick. The lower vein is four feet, dipping towards the south by east, at the bold angle of forty-five degrees. In the upper pit, the beds are half a foot thinner, and the coal is less massive. Two or three smaller and intermediate veins are penetrated, of ten or twelve inches in thickness. The strata here, as in other pits, commences with the red ground, then shale, greys, &c. Above the lower coal are nodules of iron ore, many of which are reniformed, and extremely beautiful. Both the larger veins of coal are subdivided by two thin pyritous formations, as is often the case in the coalfields, which the miners call a lism. Some of the more beautiful pyrites are cubes, whose edges and angles truncated. Sometimes glance shale is found, foliated, with arborizations of pyrites, which penetrate through all the laminæ.

Mr. White's pit, at Nailsea, has a stratum of bluish and variegated clay under the grass. Then thick beds of greys succeed for forty fathoms, divided by thin layers of soft shale and marle. A vein of dark shale next occurs, in the midst of which is a vein of coal eight or ten inches thick. This is succeeded by another order of greys for eight or ten fathoms. A stratum of bluish shale succeeds, for two or three fathoms, which is divided by thin veins of fine clay. This shale is couched immediately on the main vein of coal, mostly three feet and a half thick, and never exceeds four. It is divided into three by a lism or weak shining glance, of great levity. The dip of the main coal diminishes here from the forty-five degrees at Ashton to about eighteen or twenty degrees. In these pits is a third vein of coal twenty inches and sometimes more in thickness, which is separated from the superior coal by a shaly marl of about three fathoms, in which nodules of iron ore have elicited their stratum. The vein is six or eight inches thick, with smaller veins above, as is the general law of ferruginous formations. The coal of Nailsea is said by the workmen at the Glass-house to be more sulphurous than the Newcastle, a circumstance which seems confirmed by its greater aptitude to decompose.

Respecting these, and other coalfields in general, there is one circumstance which should not be overlooked. All strata of rocks vary, and sometimes become very thick. This is never the case with the coalfields. Where can we find an instance in which they vary much? This circumstance alone may be regarded as a presumptive proof of their having been the depositions of tides which left them behind in a very even and pure state. To which we may add, that there is no rock whatever on which the coal does not repose from the granite of the United States, to all the sandstones, shales, and limestones of this country; while, on the other hand, no proof has been adduced, that any order of primitive rocks was ever discovered to overlie the coal. Clearer demonstration we cannot have, that coal was a flotilla of the sea, which the playful element has arbitrarily reposed on this diversity of bases. Again, the superabundance of lithophytes (the harder shales containing ferns and other hardy vegetables lying so near the coal) I should think, must satisfy any unbiassed mind, that all coalfields are marine depositions of the vegetable kingdom. "Wood and pit coal wholly resemble each other in the products they yield by distillation." *Bishop Watson's Chem. Essays*, vol. iv. p. 353.

The Millgrit rock occupies, as is demonstrated by the Clutton and other pits, a position between the greys and the red sandstone. It therefore falls the next under consideration. It has happened that this formation, certainly one of the most extraordinary in nature, has been almost entirely overlooked, The name is derived from millstones made by a strong cementation of pebbles with lime, but is vulgarly called plum-pudding stone, and many of its varieties are denominated amygdaloid. Its occurrences are noticed on the right bank of the Severn, as extending to different places in Wales; and one of its most beautiful varieties is quarried about a mile from Bridgewater, and in quarries to the east of that place. On both the shores of the Avon from Portishead to Pill, and west of Blaise-Castle, it is turned up by the plow, or quarried to repair the roads. At the Pill landing-place, its stratum is level with the tide, and the whole town is built upon the rock. At Brandon-hill, near Clifton church, it has an elevation of eight or ten fathoms above the Avon, and appears with strong ferruginous characters. The well-sinkers in Somerset-street penetrate it on a level with the houses in Stokes' croft, which is nearly the same height as Brandon-hill. Passing south, across the Mendip ridge, we find it assume a more rock-like character, so as to be employed in forming stiles in the fields, in flagging the fronts of houses, and sometimes polished for chimney pieces. Here it still preserves its level position, bassetting out all the way to Wells. On recrossing the Mendip, we find it again at Coleford; and at Midsummer Norton, the stream of water runs over it. In the adjoining field it is quarried to repair the roads, where it presents an appearance to the eye like a pye of large potatoes just opened, and mixed with red earth. In the pit at the top of the hill, Mr. Hollwey informed me, it occurs at the depth of twenty fathoms, still preserving nearly a water level to Clutton, where it occupies the lowest stratum of the deep red ground. But on crossing the hill to Newton, it shoots about twenty fathoms under the Avon, from which inclination towards the east, it is presumed to spread under the city of Bath at a yet greater depth.

Though this rock is known in England and Wales to extend above fifty miles, it does not appear in any place to have a thickness of more than thirty feet, and often not to exceed ten or twelve. Its varieties are beyond calculation. Some specimens, as seen in walls, are careous, and of a purple colour. Others have a curdled appearance, abounding with white calces of lime, which do not take so fine a polish as the mass in which they are formed. Heat, as well as acids, has powerfully acted in the formation of this rock, and in so great a degree as to give a sort of semi-fusion to the more ferruginous parts of the multiformed mass. Some of the slabs after being sawn, give appearance as though white drops of lime had been let fall upon the plane. In other places, the whole rock is protuberant, and lacks the cementing power. The fractures of these nodules exhibit the strongest characters of chrystallization, and very much diversified. Though the varieties of the millgrit exceed discription, yet it often has a strong affinity to the formations of many parts of the St. Vincent rock. It differs widely however from the rock described by Professor Jameson under the appellation of amygdaloid, as having "usually a base of wackè, or fine granular disintegrated and clayey greenstone, and the vescicles are filled up with calcspar, lithomarge, greenearth, calcedony, agate, quartz, amethyst, and heavy spar." *Min.* vol. iii, p. 194. ed. 1808.

The vast and extensive marmorous ranges of this district which seem to loose themselves under the Gloucestershire hills, and extending southward towards Clevedon, and eastward through the whole Mendip ranges, fall next under consideration, as being superincumbent on the millgrit. These are often called ranges of mountain limestone; though I dispute not the term, it may be remarked, that these ranges differ widely, both in the structure and in the crystals, from the mountain limestone of the Lancashire and Yorkshire hills. With the exception of a superior hardness, they identify themselves with the Devonshire marbles in a striking resemblance, as appears from twenty polished specimens shewn me by Mr. Hay.

The sections of these ranges no where discovered themselves in bolder characters than at the Black rock, the Cleaves, and St. Vincent's, so called from a chapel which once stood on its summit, dedicated to that saint. The strata here succeed one another in more than a hundred couches, dipping at an angle of thirty, and sometimes forty degrees; but at Henbury, the dip is almost vertical, while on the Mendip range it often becomes less than twenty degrees. In the rock opposite the mouth of the Avon, the dip is toward the west.

When the stratum of the millgrit was laid on by the deluge, the whole of this district must have been a plain, slightly inclined to the east, except some of the coalfields, where deep channels have caused this rock to disappear. The black rock, as all its most western ranges, must then have been laid on as the left bank of the over-topping tides which once played in the Severn. The rock derives its name from its dark colour, and basaltic characters. It alternates to lighter shades, as the sulphurous qualities diminished, which are sensibly perceived after the strokes of the hammer. The rock becomes softer as it assumes a marmorous character. Its shades of colour proceed from various proportions of vegetable, animal, and mineral depositions. Specimens of the rock, when compared with those of the Coley-hill, can scarely be distinguished from each other by the microscope. Both those rocks abound with small cavities, now filled up with transparent crystals, but which have a dark appearance from the colour of the rock, which is seen through them. They differ, however, in three points: the Black rock of Coley is dyke-shaped, has no organic remains, and the two rents are filled with four-sided crystals, terminating with four obtuse planes set on lateral edges. The same definitions will apply to the Yorkshire Dyke, near Stokesley, which extends about fifty miles. The fracture of the Bristol rock is rough and conchoidal, fragments angular, diaphanous at the edges; colour smoke black, alternating to an ash and yellow colour. It is hard, heavy, and sonorous in a high degree. A superior degree of roughness, and the want of columnaral ranges, seem the only circumstances which distinguish it from the black rock of Rowley Regis. These characteristics give the black rock of Clifton fair claims to be classed among the weaker varieties of basaltic formations. All the dykes seem to have been rents largely filled up with vegetable depositions of the sea, which have heated to an uncommon degree.

These considerations suggest to me a mode of reconciling geologists as to the igneous origin of all such rocks. Sir George Mackenzie, on examining the lavas of Iceland, found among them frequent formations of basaltic columns. Similar remarks are made by Italian writers concerning the lavas of Mount Etna. The fact, however, is otherwise with regard to the whin, the dyke-rocks, and basaltic formations of these Islands: they never were in a state of more than great heat, or semifusion. At Coley-hill, and Titterstone Glee, the heat has been so great, as to charr the coal on each side, and to destroy all traces of organic remains, *see page* 100. The expansion and exsiccation inseparable from so considerable a degree of heat, and especially in the centre, where the heat was greatest, would cause rents, as at Coley-hill, or columns, as at Rowley Regis, and other places, which are sharply defined with three, four, or seven, in some of the pillars; but all such columnaral ranges have usually a cap rock, which being cooler, is unbroken with the excessive heat. Another circumstance attendant on these columns is too singular to be overlooked. The escape of heat would contract the length, as well as the breadth of the columns. This has fractured each column into various masses, not exceeding ten or twenty inches in length; and what demonstrates the state of semifusion of the rock, is, that the top of each fragment has a cavity, into which the lower part of the superior fragment is adapted as a bone to its socket. This subsidence in the centre has been occasioned by the columns' cooling at the angles sooner than at the centre. At the Clifton black rock, there never was a sufficient degree of heat, either to break the rock into columnaral ranges, or to destroy the organic remains; yet many of the shells are much oblated and disfigured by pressure and heat. The perpendicular fissures, however, are considerably enlarged, and the rock itself abounds with cavities and caverns.

The account of Dr. Edward Clarke, one of our most judicious travellers, is in perfect unison with these ideas. "On the north side of the harbour of Incada, in the black sea, is a series of basaltic columns, which dip at the angle of thirty-five degrees toward the sea. The substrata are of lumachella, of ochreous indurated clay, or of sandstone, and nothing that indicates the action of subterraneous fire. Therefore, as the basaltic rocks preserve the same dipping inclination as the other strata, it seems manifest that they were deposited after the same manner. The internal structure of the pillars is generally hexagonal; but it is rarely perfect. The substance of which these pillars is composed, consists of a decomposed crumbling porphyry. The vertical fissures were filled up with veins of whitish marble, three or four inches thick. From all these facts, it seems evident that the basaltic pillars of Ineada have been the result of aqueous depositions, and that their prismatic configuration, like that of starch, or the natural columns of *trap*, seen at Halleberg in Sweden, and in many other parts of Europe, is entirely owing to the crystallization which is seen in the minutest and most majestic forms." *Trav.* vol ii. page 418.

The mineral productions which abound at the black rock, as in the whole mountain range, are numerous and diversified beyond the power of description. Iron ores occur massive, nodulous, or often full of cavities. The fissures abound with ferruginous pigments of various shades, from the dark red to highly oxygenated ochres of the lightest yellow. These would yield abundance of iron, if submitted to the furnace. But iron is largely diffused through several parts of the rock. A workman on the south side of St. Vincent's shewed me a bed four feet thick, which on one side for ten or twelve inches was so indurated as to be impenetrable by their tools: they were obliged, therefore, to drill and split it with powder on the softer side.

Lead ore is found nearly in all parts of this mountain range in a greater or less degree; and often combined with ores of calamine. Nodules at Southmead, near Westbury, have been found of considerable magnitude. The matrix in which they form is yellow, alternating from a loam to a crystallized character. Calamine, the only ore which can change copper to a yellow colour, has a wide spread. It is apparently one of the most social minerals in nature, a stratum of iron being formed over it in Derbyshire; and veins of lead ore commonly formed in the centre of the ore. Some specimens have the appearance of fractured shells thrown one upon another. The edges of a few of these, have a red jasper-like appearance. Others are boitroyoidal on one side, while the other resembles the cavities of a bone. These ores, which are abundantly found at Shipham, have a redder appearance than those of Flintshire. Manganese occurs at Leigh and Mendip, in thin veins. Its ore is compact, hard, and heavy; it gives alone a beautiful light brown to earthen-ware, and forms other enamel colours by combination; as the purple-blue, and the mulberry. *see page* 42.

The small cavities in the Marmorous range abound with rock crystals, which are six-sided prisms, acumiated by six planes, set on lateral edges, and very brilliant, adhering to the red matrix of the rock. The larger cavities, as one opened lately at King's-Weston, are oven-shaped, and abound with rare and beautiful stalactites, cubes of purple fluor, ascicular crystals of sulphate of strontian. Others contain iron ores, bearing marks of fibrose vegetation, which has some resemblance to the lickens adhering to trees. The fissures of the rock are in many places completely filled up with white spar, and dog-toothed spar, semi-transparent, but often much stained with oxides of iron. These are broken small, and employed in the stucco work of gentlemen's houses, which gives them a brilliant, and incomparably beautiful appearance.

The sections of the marmorous ranges are seen also in most majestic configurations at the Clifts of Cheddar. The name is Gothic, equivalent to divided rocks. The Hebrew root, *hadar*, he honoured, as the Greek *αρματος*, and the Latin *arma*, is a primitive word which runs through all languages, and gives birth to innumerable derivatives; as Harold, captain general; Harman, Lord or chief of the army; Edgar, happy power; garrison, guardian, &c. are of the same family.* — On entering the ravine from the north, the eye is presented with a vast sheet of rubble, or millions of amorphous fragments, many of which appear careous, and much whitened by the solvent action of the air. For the space of half a mile, the eastern side of the ravine has a much bolder elevation than the western; and which very much increases during the second half-mile; then for the space of twelve or fourteen hundred yards, it becomes perpendicular, and exhibits an appearance of hundreds of church towers piled together, and rising to the elevation of three hundred feet. The western side becomes more and more inclined, as we approach the outlet to the village of Cheddar. The whole scenery exhibits the sublime of nature in her rude and majestic forms; and in some sort, so as to deceive the mind of one accustomed to examine her bolder formations.—Surely, he says, I have now left the region of flood-formed hills, and am arrived among the first formations of nature, washed and left rugged and bare by the desolations of impetuous waters! What else can be those marks on the fragments resembling the semi-indentations of human fingers; marks resembling those which the violent fires of glass-house furnaces eventually wear on the pots containing the metal. What else could have imprinted them but the violence of heat and vapour? What else, he says, can that fissure nine feet wide on the east, but contracting to one on the west, indicate, seeing it is filled up by the more and more recent formations of four beds of dull coloured spar?

In the course of one hundred yards he is compelled to abandon the idea of a primitive formation by the occurrence of a stratum copiously filled with encrinites and other extraneous fossils, all fractured, bended, and wrecked with the violent action of impetuous waters. Glancing his eyes to the west, three times he sees oozing streams, leaving pale yellow oxides on the rocks, which forbid the approach of vegetable roots: sure indications of veins of lead and calamine ores from which they proceed. He is more astonished to find, what has escaped the notice of all Geological travellers in ranges of marble mountains, a stratum of black flint about three inches thick, broken into cubes, or oblong masses; and of a hardness which the sandstones will scarcely grind. The caverns of this range are very considerable. The first we approach has its apperture on a level with the road, and preserves a parallel with its correspondent aperture on the west, dipping in conformity to the whole range of strata on an angle of eighteen degrees to the south east. The lower cavern is the most considerable, being known to contain small lakes, cascades, and large cavities abounding with stalactites, and thickly coated with spar, which daily augments in thickness. De Luc relates the old tradition of the dog, which is said to have found his way out at Wookey hole, on the Well's side of the hill. On arriving at the village, and once more seeing the open country, the ear is agreeably saluted with the murmuring of streams, They issue from a dozen apertures at the base of the rock, and form the broad head of the river, which is full of aquatic vegetables, and turns a succession of under-shot mills. These water-plants are sure tests of the salubrity which these waters communicate to the inhabitants of Cheddar.

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* See Baldwin and Co's edition of the author's English Grammar, appendix No. II. 4*s. bound.*

Speaking here of water, we are prompted in order, to return to the Hotwells of Clifton. These have their source in the basaltic or sulphurous range north of the Avon. The rains descend through the fissures, and often form pools in the cavities of the rocks, and collecting their strength in the gravel at the base, issue forth in fountains, whose qualities faithfully discover the minerals through which they pass. They equally discover, as is the case with rivers, the extent of their course by the strength of their stream. When the well was dug at Sheerness to the depth of three hundred and thirty-three feet, excellent water was found in a bed of gravel; but Mr. John Sole (now Master Carpenter of the King's Yard at Deptford) who made the wood-work, informed me, that a well was instantly dried up, ten miles across the Thames in Essex. The waters of the Hotwells have likewise a wide and extensive spread. They issue forth in moderate streams at the low-water mark, both at the well, and also at the cottages a mile below, besides intermediate oozings. In 1796, the late Mr. Morgan of Zion-Hill, penetrated the whole rock to the depth of two hundred and forty-six feet, and discovered the water in a bed of gravel.

The Bath waters, and those of the Hotwells, are estimated to have their source in the same basaltic range, though they considerably differ in qualities and temperature. Those of Bath are more copious, and issue in three streams, which are formed into distinct baths. The waters of the king's fountain would turn an over-shot mill; and those of the cross bath, and the queen's bath, are considerable. The strength of the stream will partially account for the variations of heat. The temperature of the king's bath is 116, while that of the cross bath, having a weaker stream, is cooled in its course to 112. The water of the Hotwells is not higher than 72 or 76. Few of the spas of Europe exceed the temperature of the Bath waters, except Carlsbad, or *baths of Charles*, in Bohemia, which equal the temperature of boiling water.

With regard to the cause of superior heat in certain places, we have demonstration in several of our collieries. Great heaps of small coal thrown together, and abounding with pyrites, have spontaneously kindled to combustion, as some have erroneously supposed by ignited gas. Some years ago, the alum shale of Boulby cliffs near Whitby, fell down; being thus freely exposed to the air, the mass ignited, and continued burning for a long time. These facts, not only justify the experiment I have translated from Professor Henckell, that if forty pounds of oxides of iron and pyrites be ground in water, the mass will increase in heat to combustion, but demonstrate the cause of the widely different temperatures of fountains. A gallon of the Bath water is said to contain eight ounces of carbonic acid, and nearly the same quantity of azotic air, eighty grains of solid ingredients, half of which is sulphate and muriate of soda, fifteen grains and a half of flint, and what remains is sulphate and carbonate of lime, with so small a portion of iron as to be scarcely perceptible. These minerals cause the water to be one tenth heavier than that of the Avon. The acids have been known to corrode a bar of iron (which had for some purpose been placed in the king's bath) till it was full of holes like a honeycomb; and they coagulate milk at a boiling heat. The qualities of the Hotwells' water differ from those of Bath in a small deficiency of acids, and in the colour of the sediment after evaporation: the former has a higher red, the latter a more ochrous appearance. Both the sediments, when burned in a dark room, give a blue flame, emit a strong smell of sulphur, and effervesce with acids. It is these acids throughout the whole basaltic and marmorous range which cause a continual process of decomposition to be going on, and generate heat in the water. Why then frighten us, as the London Guide to the Baths of England, with the ideas of subterranean fires, and volcanic explosions?

It should not escape remark, that these heavy waters relieve themselves of the noxious load by ochrous depositions at the sides and bottom of the stream. During the excessive heat of summer, I have seen toads, and once a serpent, lying dead near a mineral spring. The poor animals had come exhausted with heat and thirst, and drunk so profusely of the water as to sicken and die ere they could reach six feet from the stream. The same spring, medicinal, no doubt, in many cases, in the course of a mile apparently ceased to make depositions, and became more salubrious.

It is an opinion which has obtained in this neighbourhood, "that the abrupt and continuous chasms, as seen at Cheddar, Clifton, and Chepstow, have been the result of catastrophes in this range." The similarity of the sections of the rock in one place on each side of the river at Clifton, seems to favour this idea; and having admitted (as in page 99) the rents and disruptions in Cornwall, and the north of England, I have felt prepossessed in its favour. An examination of facts, however, has compelled me to retract. My reasons are, 1. That a similarity of structure in the bolder piles of rocks on each side of rivers, are by no means occurrences connected with disruptions. 2. The rents in dykes are nearly in parallel lines, and seem to have been slips of the diluvian mass filled up with extraneous depositions by the next tide; whereas, the course of the Avon is no where so serpentine as from Clifton to Pill. 3. The strata at Clifton, and the caverns at Cheddar, are perfectly parallel and undisturbed; now, it is scarcely possible for such a disruption to have taken place, without a slight subsidence on one side. 4. It is much more probable that the return of the equinoctial tides, during the latter period of the deluge, forced most powerful currents through all such rocks, leaving mural precipices in confined places, and desolating the summits and craigs of secondary rocks, I would say, the rocks formed a few months before by the first great strokes of the deluge: for all geologists grant, that rocks are crystallized; and all our chemists affirm, that crystallization is rapid in its operations.

To the east of Clifton church, adjoining to Brandon-Hill, a rock bassets out which may be denominated a quartzose sandstone. The thickness of this rock is not considerable, nor does it extend very far. When viewed in the microscope, the crystallization is one continuous mass of a milky white colour; but largely interrupted with the red brown oxides of iron, and which often sport their beautiful wavings in the mass. The crystallization resembles the sandstone brought to London from Leith Craig, or the callierds, or rather calliards of the north, that is, of a hard nature; for the desinence *ard* in all Gothic words signifies nature. These are local and superior formations. On the east side of the quarry, near the graveyard of the above church, iron is so largely combined with the rock as to give, on the exterior of some parts, the appearance of a semifusion; as is the case with the adjoining millgrit of Brandon-Hill. This rock is of inestimable value for paving the streets. It is so durable that it has never exhibited the least decay, and its beauty is of the first order.

The old red sandstone is seen cropping out at the cockpit with the bold dip of 55 degrees to the north west; but through Frenchay and Stapleton, with merely a slight inclination towards the east. It is composed of very fine lucid grains; and its red, brown, and often grey and bluish colours, proceed from the different states of the iron, and different natures of the strata with which the iron is combined. Its strata, like most of the flood-formed rocks, consist of thick and thin beds. The thicker and harder are quarried for troughs and masonry work. The bloodshot parts of the rock are the hardest when first quarried; but in process of time, the iron is found to oxidize and decompose;. other parts of the rock are shelly, which disfigures the pavements of courts and paths; but the prime parts are found to stand the tests of time.

On comparing specimens of this rock with the red sandstone of Liverpool, I am not able to discover the least difference. Varieties indeed occur here, as in the Staffordshire and Lancashire districts. On the road from Leek to Buxton, it is seen rising with obtuse prominences; but in the neighbourhood of Leek, and not more than two miles from the obtuse rocks, it alternates very much. At Uttoxeter, it begins to assume a more quartzose character, being mixed with very large crystals. It assumes an equally gritty appearance north of the forest of Dean, where millstones are quarried. But though the general characters of the rock be the same both here and in the north, there is, in this district, a total deficiency of the white sandstone rock, which is largely used for building in the north. At Mowcop, six miles north of Burslem, this white sandstone raises its high head in the centre of the red sandstone district, and shoots under it, no doubt, to a great extent. Northwards, we find it the constant companion of the mountain limestone, spreading through all the west of Yorkshire till it reaches the ōŏlite, and earthy limestone of Doncaster, and all the eastern counties. My friend, Mr. Whitacre, one of the gentlemen who lately built the new bridge over the Ouse at York, told me of a remarkable occurrence, which, at that time, attracted the notice of the public prints. During his apprenticeship, while splitting a white sandstone near Chorley in Lancashire, he found in the midst of the block, a toad in a torpid state. On being dislodged, it shewed signs of life; but presently died. The blood was fresh as in other animals.

The paucity of organic remains in all the orders of sandstone has been a subject of astonishment in geology. Mr. Bakewell judiciously observes, that they do not occur in gypsum, the sulphuric acid having dissolved them. This remark, I should think, applies with equal force to all the softer shales in the coalfields, and to all the arenaceous formations. We find abundance of organic remains both below and above, though imperfectly discernable in the rocks themselves: the acids have destroyed them in the powerful processes of mineralization. This, however, is far from being always the case: the stronger remains of vegetables and animals have, at least, so far resisted as to retain their figure. The trees which are very numerous in the quartzose sandstone of the Isle of Wight perfectly retain their figure. Mr. Aspinal, a man of experience near Halifax, found a large tree crossing his beds: the workmen were divided in opinion about it, the tree and its branches being identified with the rock, and differed solely in the figure; but when the darker ramifications of the roots were laid open, it terminated the dispute. The opinions of practical men are generally entitled to deference, because of their superior acquaintance with local facts: their unfounded inferences mostly arise from the circumscribed state of their knowledge. At Nailsea, as in many other places, there is a large bed of sandstone full of black marks, which indicates the remains of vegetable combined with oxides of iron. At Frenchay, a vein of coal occurs, a quarter of an inch thick in the solid rock; the remains of animals have been found there. Mr. Phillips mentions a vein of coal two inches thick in the red sandstone of Shropshire. Lithrophytes have occurred in the quarry on Brislington common, not only small black marks, but broad leaves of the algæ class, bamboo canes have been found.

In the general range of this class of rocks, there is one remarkable occurrence, which, I think, is never found in the white sandstone; it is the formation of globular nodules in the heart of the rock, and separated by a thick coating of oxides of iron. I have seen some of ten and others of forty inches in diameter. In the coalfield, where the sandstone is superincumbent on the vein of coal, these nodules are oblated at the bottom, and on that account are called *bell-moulds*. They are known to the colliers by fatal experience, for while the miner is working in an inclined position, which is always the case where the beds of coal are thin, the continued strokes of his pick gradually loosens the bell-mould, which eventually drops out of its socket, and kills or maims him without the least warning.

From the old red sandstone we proceed to the red ground, which overspreads nearly the whole of this district, and has a larger extent through

Devonshire, and the north of England. This ground contains the soft brick-coloured sandstone in the lower parts of its beds, and the beautiful shaly lias in the higher. In many places, however, the lias occupies low situations, and is in immediate succession to the alluvium of the vallies.

This white lias, appears immediately under the turf in a rubble, the usual approach of rocks. To the depth of twenty or thirty feet, or twice that depth in many places, a succession of beds appear, varying in thickness from the slaty figure of less than an inch to two feet. These are divided by veins of clay two or three inches thick,. and sometimes two feet thick, mixed with rubble. The clay, when dried, breaks into a shale. This lias is denominated in modern geology, floetz (the German for flat) limestone of the third order.

The rock is cream-coloured on the exterior, but often darker in its fractures. But whole couches both of the rock and the clay are beclouded with pale blue. The shells in the white lias have the colour of the rock; while in the blue, they assume the colour of London smoke, as is the effect of iron on hides and animal substances. These clouds equally affect the secondary ōŏlites of Purbeck, and the whole range to the eastern sources of the Avon. The fossil-fish, as well as the testaceous, participate of the colour.

The fracture of the white lias is conchoidal, often flinty, sparry, and sometimes rough; the edges are diaphanous; lustre glimmering; and the thinner strata sonourous in a high degree. Other parts of the rock have a compact fracture, less glimmering, often cavities occur nearly filled with iron in an ochrous state, while other cavities contain brilliant yellow pyrites. At Cotham, and towards Frenchay, a stratum occurs toward the upper part of the rock which has a rough appearance; but on being sawn and polished, a beautiful landscape is presented to the eye, having the river in the lower ground, with an elevation in the upper, of rocks, fissures, and the semblance of trees.

I think it is not to be questioned but these rocks and strata were among the latest depositions of the diluvian tides, as they contain some of the identical ammonites which occur in the Black rock, and belemites as in ōŏlite, with innumerable testaceous fish which once inhabited the deeper seas.

The shaly lias after calcination yields a brown lime, which is very strong and rapid in its power of crystallization. On that account, it is preferred for the foundation of bridges, and other masonry under water. Those parts of our marmorous ranges, denominated mountain and magnesian limestone, yield very white calces.

Utility being the best end of science, I would beg leave to advise the husbandman to lead his lime warm from the kiln, and instantly spread it on his fallowed field, that it may decompose for fourteen days at least, and imbibe the saturating moisture and nitre of the atmosphere before he plows it into the ground. But I would prefer his only barrowing it in. The general practice of letting the lime shoot its crystals at the road side, or of plowing it in immediately on being spread, is the sure way to have a weak crop. The magnesian qualities of the lime require a full exposure to the air. For grass land, designed to be plowed in the spring, I recommend the Derbyshire practice of laying on the lime in August, which produces an early vegetation in the spring, and is cropped by the sheep before the land is plowed for oats. The following experiment will, perhaps, afford some illustration of the propriety of these advices. Take twenty ounces of lime hot from the kiln, break it rather small, and spread it on an earthen dish, and the first week it will imbibe water and nitre so rapidly as to weigh twenty-six ounces. In a week more, it will weigh about twenty-nine ounces, and in nine months, thirty-five ounces. This experiment does not so exactly apply to lime burnt from chalk.

With regard to organic remains, the marble, often alternating to magnesian limestone, the shaly limestone, and the ŏŏlite, contain the genera, the families, and species of shell fish, madrepores, coralties, encrinites, pentacrinites, far beyond what scientific men have attempted to distinguish. "The book of nature," as Bishop Pontoppidon observes, "contains many leaves which no mortal ever yet perused." Mr. John Walcott has very accurately painted and engraved about sixty shells, besides leeches, bones, and palates. Mr. Sowerby, in his beautiful coloured work on shells, has published many others; but these do not contain the fourth part of what exists in gentlemen's cabinets. This science, which merits the most enlightened classifications and the best powers of the pencil, is yet in a state of infancy. But of seeing it brought to perfection, one can have little hope, learned men having unaccountably committed themselves by contending, that in every fresh order of strata, we meet with an entire fresh order of extraneous fossils. It is granted, at once, that we do meet with such order, for the works of the Creator are immense; we meet also with fresh plants in every continent; nevertheless, in all these fresh orders of strata, we meet with many shells and plants found nearly in all the other orders. These are facts founded on personal examination, and the severest scrutinies. These are facts which command the judgment, and must eventually supercede the contumacy and novelty of our modern theories. No man will surely tell us, that the belemites, the ammonites, the ostracites, the trochites, the nautilites, and gryphites, found in the lowest strata of the alum shale of Yorkshire, are of a totally different order from those of the same name in this district, and in the chalk and limestone ranges of the south of England. I have seen three of the Yorkshire ammonites which differ from those of the south, one of which had mouldings on the whole spiral coil resembling the edges of the oak leaf.

While speaking of fossils, we may here add, that many geologists on the continent enjoy the full triumph of absolutely denying the existence of any human remains in the transition and the floetz classes of rocks. How long this joy can subsist against the occurrence of stubborn facts, is not for me to determine. In addition to what is said page 74 and 75, it appears from the article on Mineralogy, written by Mr. Bird in the history of Whitby, that three human skeletons have been found at different times in the alum shale; and though Mr. Bird affects to doubt, he does not at all impeach the credibility of the witnesses. Mr. Whitehurst assures us, that all was done that could be done to hinder that found in 1745 from decomposing. In the forty-third volume of the philosophical transactions, a fourth is reported, as found in the mountain limestone of Derbyshire, with harts' horns, while driving a level to a lead mine. A fifth is given in the large work of father Athanasius Kircher, and accompanied with a drawing. It was found imbedded in the solid limestone at villa Ludovisia near Rome; and which Kircher describes in these words, "Spectantur et hic Romæ in horti Ludovisiani palatio, corpus humanum totum in saxum conversum, ossibus adhuc integris, at lapideo cortice obductis. *Mundus Subterraneus*, lib. viii, cap. 2. This fossil has since been noticed by several English travellers.

The red ground contains many other formations of great interest to the geologist, and largely so to the mineralogist. Veins of gyps often occur; some of these cover the limestone with thin coatings, while large veins present themselves near the new passage. Selenite is of frequent occurrence in the gyps. In the year 1728, while digging to the Hotwell spring, many of these were found in a vein of yellow ochre.

At Winford, there is a vein of very superior reddle, used for colouring sheep, and for pigments. It is of a much lighter colour than the reddle of Braithwell near Rotherham; and on that account has often been sold for red bole.

At Coomb Hay there is a vein of fullers' earth; and, no doubt, the like veins occur in other parts of the country, if the well-sinkers did but know them. The exterior colour is not dissimilar to the Hampshire and the Bedfordshire earths; but the interior exhibits a dull blue, like the blue clouded parts of the white lias, or the Purbeck stone. The fracture is compact, with an earthy appearance; it yields to the scratch of the nail, and abounds with very minute scales of mica. It dissolves quickly in water, and coagulates, if the water be slightly mixed with acids. This earth has been much enquired for by foreign chemists.

Strontian earth is another formation very general in the red ground. About a hundred yards above Bedminster bridge, it may be seen at low water in veins of five or six inches in thickness, forming a sort of network. Brick-makers burn it for malm bricks. In other places, it alternates to a rocky appearance, with very minute scales of mica. The colour when first fractured, is a very light shade of green blue, and certainly one of the most beautiful in lithography. It apparently refuses every vestige of pollution from the red soil with which it is thickly coated. Many sulphates of this earth have been found, which find a place in the cabinets of gentlemen.

The ōŏlite is the rock which immediately succeeds the shaly lias, still following the dip of the strata towards the east. This rock is justly regarded as one of the most beautiful and useful formations which nature can boast. Its sections are best seen at Coomb Down, Winsley, Painswick, and Winchcomb. It covers the whole ridge south of Bath, rises at an equal elevation at Stoke, Freshford, and Wraxall, and stretches along the Gloucestershire hills. At Coomb Down, it discovers seven beds, each of which is three, four, or five feet in thickness. All the beds contain some shells, but the fourth is so full, and often of large shells, as to be unfit for building. The cavities of those shells contain crystals which rise in columnaral ranges, from which small four-sided crystals shoot out, very much acuminated. The rock itself is so soft as readily to yield to the saw, and to the strokes of the hatchet; but it becomes very hard by exsiccation.

The geological situation of this rock differs from that of Portland, which has a cap rock that will burn to lime; and an under rock, called the horse hair bed, being full of black strokes resembling short thick hairs. The Bath stone lies on a blue shelving rock, which deteriorates to a shale. The navigation at Winsley has discovered a second order of ōŏlites about forty fathoms below the superior stone of the quarry. This is presumed to be the case with all the ranges of this stone. The like succession of toadstone and limestone occurs in Derbyshire. This succession is a general law of nature, which repeats, as well as diversifies, her formations. The chalk rocks conform, in all their greater ranges, to the same law. Yet the formations of the ōŏlite are no where so good as on the brows of hills, where they are reposed for the easy access and immediate use of man.

The varieties also of this stone are subjects of equal interest to the students of nature. The Portland ōŏlite is whitish from its approximation to the chalk, which has very often occasioned nodules of flint to form in the beds; while the Bath exhibits a beautiful basket yellow, which proceeds, according to Kirwan, from a high state of oxygenation in the iron. The fractures are angular, and appear to the eye as a rough formation; but on submission to the microscope, the rough particles of the stronger formations are globulous. The Ketton stone puts this point beyond dispute. Its particles very often are so large as to resemble the roe of a fish, which has given to the rock the name of roe-stone. In decayed specimens, each globule contains a cavity, which is partly filled up with a softer substance. At Winchcomb, in Gloucestershire, the globular character of the stone so far alternates as to admit of small scales to be mixed with the globules; all of which are the different effects of crystallization. Yet the stone is thought by many to be slightly impaired in beauty by this admixture. The Painswick variety has a fine grain, and is more compact, on which account it is preferred for ornamental works. The Yorkshire ōŏlites, as seen at Doncaster, Thorparch, and northward, are more white and compact, which give it an approximation to the earthy limestone, as seen near Ferrybridge. In the vale beyond Pickering, it is really burned for lime; whereas the rocks in this district can not be denominated more than semi-limestones formation.

The secondary order of ōŏlites falls next under consideration. The range extends from the Isle of Purbeck to Ditcheat, Steeple Ashton, and various parts of the north, occupying an eastern parallel to the purer formations. The exterior colour of the masses differs little from that of the more perfect stone, but the fracture is sometimes sparry, sometimes compact, and sometimes approaches the roestone; and the interior colour often alternates, like the shaly lias, to a dull blue. The superior parts of this rock have often a slaty character, widely used in the clothing districts for the roofing of houses. The rock itself is of a much harder nature than the Bath stone, and sometimes, as always formerly, is used for repairing the roads.

In extraneous fossils, as well of the vegetable as of the animal kingdom, no rock whatever is more pregnant than certain strata of the inferior ŏŏlites. It was from the slaty formations the quarries adjacent to Bradford and Steeple Ashton, that many of the fossils were dug which are engraved in the Crinoeidea or Lily-shaped Zoopites, a work just published by Mr. John S. Miller. The assiduous author, has given us the genera of the Encrinus and Pentacrinus, with observations on the genera Marsupites, Alecto, Euryale, and Asteria. In all the marmorous ranges of this district, of Derbyshire, and of the chalk formations, there is such a general wreck of zoophites, as to excite regret that no perfect one was ever found. That complaint, at length, exists no more. Strong traces of nine genera, and twenty-four species are given in the above work, painted from originals in the cabinets of gentlemen in this neighbourhood, many of which have the most exact resemblance of the screw stones, &c. of Derbyshire.

The City of Bath is known to us geologically only as seated on the shaly lias, which appears in the quarries west of the town; the lower part being built on the alluvium of the river, is little known, as not one of the wells is deep. It is solely by the mineral stream, that we infer its basaltic relations. There is indisputably a black rock to the north of Bath, as adjacent to Clifton, which is demonstrated by the qualities of the water. These formations have been influenced by a superabundance of iron, of sulphur, of animal and vegetable depositions, from which the qualities of the water, with the frequent appearance of bituminous oil, proceed.

Of the alluvium of the Avon, little is dissimilar to that found in most other rivers. Trees, and organic remains of herbivorous animals are of general occurrence. In digging the new cut in Bristol, oak trees, deers' horns, boars', and other teeth, gravel, blue sulphate of iron formed in the clay, were found. The plastic clay of rivers, which is very abundant in the Thames, being the sediment of former operations, is too weak to promote the formation of rocks; yet there are shaly rocks in it, and many slight veins of iron, with abundance of capillary sulphate of iron. But having described these, page 45, and 102, I still, as Dr. Edward Clarke, and others, attribute the deposition of those trees and bones to the inundation of Ogyges. "I do not deny," says Mr. Ray, "that there was such a particular flood in Thessaly, as that called Deucalion's, about seven hundred and seventy years after the general deluge. I acknowledge also a more ancient flood in Attica, in the time of Ogyges, about two hundred and thirty years before Deucalion's, that it lay waste, uncultivated, and without inhabitants, for almost two hundred years." — *Three Discourses*, *page* 68, 1721.

These basaltic and sulphurous ranges north of Bath lie deeply covered with the primary and the inferior ŏŏlites of the Gloucestershire range; the eastern declivity of which gives several streams to the Avon. But as we proceed, at Melksham, and several other places, the Cornbrash limestone makes its appearance, and extends for seventy or eighty miles in the direction of Oxfordshire and Bucks; but with frequent interruptions. It conforms to every order of calcareous rocks in its power to preserve organic remains. Mr. William Smith, in his Stratigraphical System of Organized Fossils, mentions the modiola, cardia, ostrea, cavicula, and terebratulae, as occurring in this range. The rock is stratified, dips at various angles, conformably to the primitive base, to which, in the order of the strata, it is related. It has a whiter appearance than the lias, and often alternates to an arenaceous character. In its general characters, it must be regarded as a daughter of the ŏŏlite formations, which lightens its shades of colour on approaching the chalk.

In several places towards the sources of the Avon, a rock makes its appearance, which differs from our shaly lias in the thickness of the strata; but its beds are equally divided by clunch clay, and which has, for what reason I know not, been denominated *forest marble.* The clunch clays are alike the weaker remains of the Cornbrash, and the forest marble formations. They are both good limestones, both abound with extraneous fossils, and form an intermediate order of rocks between the ŏŏlite and the chalk.

The new canal cut along the Avon from Bath to Melksham, and thence branching off to the hills of Devizes, has laid open the ground, and more fully discovered the strata of which that district is composed. A course ŏŏlite, often alternating to blue, is of constant occurrence. The beds of clay are yellow, variegated, and blue. Both the ŏŏlites and the siliceous clays, abound with extraneous fossils. Beds of sand, micaceous shale, and green earth, accompanied with blackish veins, occur in undeterminate succession. The rubbly, and uneven character of the stone dug in many of the quarries, are sure indications that they are only the approaches to rocks of a more massive form. These sands and rocks constitute the general outline of the strata to the sources of the Avon till we arrive at the chalk, from which the river receives its most powerful springs.

On approaching the commencement of the downs, we are presented with conic hills, and bold cliffs. The cliff of Westbury, and that of Calne, are so bold, that they present us with the white horse, once adored by our fathers. The turf being cut away, whitish chalk and marl exhibit a fair figure of the animal. The chalk formation, I do now as when residing in Kent, regard as a continuation of the marmorous ranges of this country. When seen *in site,* as described in page 69, it is a regularly formed rock, having beds, fissures, and inclinations, and reposed, as is generally the case with marble mountains of the transition class, on a gravel. But it is a rock almost reduced to the calces of lime by some unknown cause, which has separated the siliceous fluid, and caused it to elicit a veinigenous and nodulous situation conformably to its own determinate laws. The distance and magnitude of these siliceous veins, are proportioned to the once strength and qualities of the depositions of the tides. The chalk, as is the case with the mountain, the magnesian, and subordinate calcareous formations, has converted all the extraneous fossils into its own substance.

The silica has likewise transformed them all into real and pure flint. This demonstrates that the change, or semi-destruction of the chalk was effectuated from the very first chemical conflicts of the diluvian depositions. But on the conglommerates of granite, and other massive fragments of rocks, being previously formed, no change has been induced.

The difference between the transition marble and chalk rocks, and the primitive, is very striking. Dr. Robert Townson says. "I have followed a great chain of primitive limestone mountains [in Hungary] for perhaps a hundred miles; yet they never appeared to be divided into regular beds, though they were some hundreds of yards in height." —Philosphy of Mineralogy, p. 70. See extracts from other travellers, p. 95, 96.

Add to this, that after admitting the new genera, and species of extraneous fossils which occur in the chalk, the organic remains are much the same in both those larger proportions of terrestrial formations. We find Belemites, coralites, alcyonia, ostrae, pectines, terebratulae, with wood, and the remains of animals, as in the shaly, the argillaceous, and calcareous formations.

Our first approach to the downs presents us with silocious rubble or superior oblate and amorphous flints, sporting their clayey colour to those of red, yellow, purple, and all the tints common to the calcedonies. We lose our beds of sands, our limestones, and ōōlite apparently under the new order of the *Albuin* hills, as the ancient Britons called this part of the country. Strong and pure fountains issue forth in the gravels, which seems to separate the deeply dipping rocks we leave behind from the chalks, the sands, and clays, which succeed. The gravels and sands, being the crystallized detritus of the old world can promote no new formations; and the plastic clays, being the much exhausted and gradual depositions of tides since the deluge of Noah, promote only rare and weak formations of iron, shale, crystals, &c. &c. Here then barriers are set to further research. Here we check the presumption of a daring imagination. Reasoning from facts we know, a sure mode on many points, might here be erroneous; for the Creator, rich in resources, diversifies his works. Our researches are everywhere circumscribed by the immensity of those works. Our too presuming reason, humbled by heights and depths, has no retreat, but to adore at his feet, and to ask grace to make a right use of knowledge, that we may love and imitate him the more, and in every possible way, through all the future walks of life.

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OF THE EARTH:
IN WHICH
The Mosaic Account
OF
THE CREATION AND THE DELUGE
IS VINDICATED.

CA·BODLEIANA

2

By JOSEPH SUTCLIFFE, A. M.

"O Lord, how manifold are thy works! in wisdom hast thou made them all! the earth is full of thy riches. Psalm civ. 24.

. . . . Rebus quisque relictis
Naturam primum studeat cognoscere rerum. Lucretius.

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INTRODUCTION

TO

GEOLOGY, &c.

THE human mind, in all its researches after truth, deserves the most liberal aid that science can afford, because in the study of nature it aims at the discovery of cause and consequence, and thence at a deduction of the moral and religious obligations of man. The immensity of things yet to be known, connected with want of leisure and want of means, does not discourage research, because the task is but commensurate to the immortality of existence. In the progress, we are allured and rewarded at every step, not only from discoveries new to us, and valuable to society, but from traces the most striking of the wisdom and goodness of God, and from his incessant cares of our happiness and welfare. The natural theology of Moses, in the genesis of nature, and the ravages of deluge, is written confessedly to make known the being and perfections of God, and to cause him to be worshipped and revered. The chronology he has given of the first twenty patriarchs, by whom the earth was peopled and repeopled, is distinguished by a simplicity and precision, which convey the most luminous satisfaction to the calm enquirer.

The ancient Egyptians, it is true, did boast of a chronology much more extended than that of Moses; but a chronology which stands charged by Diodorus Siculus with reckoning moons, and sometimes seasons for years. It is contradicted by their own mythology, or rather harmonized with the Mosaic history; for their god, Jupiter-Ammon, was no other than Ham, the son of Noah, whose name is joined with that of Jupiter or JEHOVAH. It was not uncommon for ancient princes, and even for private persons to associate the name of God with their own name. The seventy-two Jews who translated the writings of Moses in Egypt, under the auspices of Ptolemy Philadelphus, have not disturbed his chronology, except by the addition of Cainan after Arphaxad, which adds a hundred years to the Mosaic account, and may have been an omission by transcribers of the Hebrew text.—The Chinese, as well as the Egyptians, boast of a very extended chronology, which is not believed except by themselves. The record of a long day, which the Egyptian priests shewed Herodotus, the protracted day of Joshua, on reaching China, is extended to the space of eleven days*.

There is, however, no necessity to revive here the controversy which once disturbed the Grecian schools, concerning the eternity of matter, the spontaneous formations of atoms; and whether the soul were but a more refined organization of the same mass. Pythagoras, Socrates, Plato, Aristotle, and others, continued to maintain the barrier against the influx of principles so destructive of the moral happiness of man. Dr. Cudworth, in his *True Intellectual System of the Universe*, spent the better periods of his life in bringing forward their ancient arguments, connected with the advantages of modern literature, with a view to put the free-thinkers of his time entirely out of countenance. Moralists, poets, and divines, acknowledge their obligations for his labours.—But truth must still be clad in armour. The warring passions of men against the laws of heaven, ever raise their weapons against the doctrines of revelation. Every now and then, a new enemy approaches our flank, wishful that we should not perceive his manœuvres, till he has struck the blow. He approaches in the garb of science, and gains our ear as the friend of reason and of truth. Having obtained some ascendancy by his wisdom, and pleased us by his eloquence, he slides imperceptibly to the eternal war which the ocean has waged against the cliffs and promontories; and to the immeasurable periods which our continents have endured.

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* See a translation of an original document in Stackhouse's History of the Bible; article, Joshua.

Now, if these doctrines be really founded, and by fair deductions from the characters of the earth, then Moses is in error, and the ancient patriarchs were ignorant of the origin of the world; then the claims of revelation are nugatory, and impositions on the credulity of the public.—If the history of nature do not afford arguments, and speak with a thousand voices of conviction to the mind; if the earth itself do not furnish chronometers of a comparative juvenile existence, we have but to retire in vanquished silence, leaving the palm in the hand of infidelity. Because, if matter really be eternal, the Being, to whom we ascribe the glory of creation, is dependant on matter; and no longer a free, but a necessary agent, who ought not to be adored, because he cannot hear, he cannot save.

Just the reverse of this is the Christian faith. We believe that the Supreme Being alone is eternal, independent of all creatures, and infinitely happy in himself. We regard the creation as a voluntary overflowing of his goodness, that intelligent beings might be happy in the contemplation of his works, and in the enjoyment of his favour. We admire the creation in order to adore the Creator. We see all nature full of his perfections. In the immensity of the creatures, and variety of their forms, we trace the wisdom of a God, who, in the formation of every creature, and the connection of cause and consequence, had every possible plan before him, and has, in all cases, chose that which was best. Foreseeing the solar influence in the torrid zones, he has provided cooling fruits to allay the heats of fevers, breezes almost constant to cool the air, and provided the camel with an upper stomach, to hold a supply of water while crossing the parched deserts. Equally aware of the northern cold, he has there provided more solid food for man, the warmest wools for sheep which prefer the hills, and soft and open furs for beasts which pierce the thicket. Every creature in the mineral, the vegetable, and the animal kingdom, alike discovers his wisdom, his goodness, and his care. Hence arises the impossibility of super-adding the least improvement to the works of nature, for whatever has once received the finish of a God, can never receive the smallest augmentation from the genius of man.

The contrast, therefore, between the believer and the unbeliever is wide and striking. While the mere geologist contemplates the mines and abysses of nature; while he is awed by the falling of precipitous cliffs; and while he trembles at an imaginary sinking of continents, and the consequent rise of others, out of the sea, he looks into the abysses of his tomb, the tomb into which he is about to fall and rise no more: whereas the Christian student looks through all nature with cheerful eyes. When he sees the mineral kingdom abounding in beauties, beauties which in their kind equal those of the vegetable and animal kingdom, he is transported with the thought, that the God who made all these beauties by his fiat, is himself infinitely more glorious than his works.

It is, therefore, proposed to take such a survey of the earth's upper surface, as shall tend to the increase of our faith and piety, and be a short introduction to the study of geology.—The term is derived from γη, the earth, and λογος, word or discourse; equivalent to a treatise concerning the earth. And to avoid whatever may be visionary in some theories of the seventeenth century, it is intended to reason from the effect back to the cause, taking, at every step, simple nature for our only guide. Her laws being invariably the same, it must be a maxim the most assured, that her present gentle formations of bodies first decomposed, are but a continuance of all her grand exertions in the first creation.

Cicero has delivered it as an opinion generally received among the ancients, that *fluidity* was the pristine state of the chaos of which the earth was formed[*]. Our learned countrymen in India have there discovered a similar tradition. When the Bramins solicited *Menu*, son of Brahma, to give them some account of the first creation, he spake thus;—"This world was all darkness, undiscernible, untistinguishable, and altogether as in a profound sleep, till the self-existent invisible God made it manifest with the five elements, and with other glorious forms which perfectly dispersed the gloom. Designing to raise up creatures, by an emanation of his own glory, he first created the waters, and impressed them with the power of motion. Hence the waters are called nárà, because his first *agana*, or moving, was on them[†]."

The Genesis of Moses is perfectly coincident with the universal tradition of the ancient temples. "In the beginning God created the heavens and the earth,—of things which do not appear, (and which existed only in the Divine mind.) [Gen. i. 1. Heb. xi. 3.] darkness was upon the face of the deep; and the Spirit of God moved on the face of the waters." This doctrine, handed down by universal tradition, is applauded by reason, and confirmed by experiment. Matter, in a liquid state, is the easiest of operation; for, in chemistry, operation by fire often tends more to the confusion than to the exact analysis of bodies. Water is the state by which all nature is nourished; and the state to which the most indurated substances may be again resolved. Gems, the hardest of the silica family, soon dissolve by the action of acids: platinum, the heaviest of metals, and most difficult to fuse, presently disappears in three parts sulphuric and two parts nitric acid, when exposed to less than a boiling heat. Alumine, or clay, formerly said to be insoluble in water, is now found to disappear, in a considerable proportion, when exposed to the powerful heat of a digester, filled with about a thousand times its quantity of acidulous rain-water; and all clays so dissolved, proceed, on evaporation, to form their respective chrystals.

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[*] Aquam (dixit) esse initium rerum, Deum autem eam mentem qua ex aqua cuncta fingeret. De Nat. Deor. i. cap. 25.

[†] Asiatic Researches, vol. i. page 243.

This principle being established, we may be further assured, that the liquid chaotic earth, cemented by affinities, and attracted by a central gravity, would choose a globular figure; for so is the figure of all the celestial bodies; so is the figure elicited by the pearly dew, on the spacious lawn; by drops in the falling shower, and of the heaviest metals, until an increased quantity of weight determines them to other forms.

Again: the new-created orb, having the simple essences of all things within itself, would instantly proceed to obey its Creator's pleasure, and carry all the laws of matter into the fullest effect of chemical energy. The escape of light would put the whole in motion; and motion would excite the latent heat: the acids would curdle the whole interior orb; would neutralize the alkalies; and the curdled masses being attracted in various proportions, would form, by the affinities which reign through all nature, substances, new in essence and diversified in species, beyond all that the classifications of mineralogy are able to distinguish*.

It is also to be remarked, that ere the light and air escaped, the various masses, greatly strengthened by the exuding of the water, and by a closer union of their parts, would severally commence their grand peculiar process of chrystalization, and form the vast and diversified masses of granite and calcareous rocks, as they now exist in the primitive earth.—The argilla are apparently the sediment of these operations, which, in all cases, vary in qualities, as the rocks and mountains vary to which they are contiguous. The Cornish clay, for instance, differs little from the Cornish quartz, as appears by analysis, except in a deficiency of two-thirds of the silica. The proportions are much the same between the various marles and the calcareous rocks, from which they apparently are secreted. The purer silica fluids, so diversified in genera, species, and tints, would sport their formations in nodules, from the massy flints to the minutest sands. While the heavier and stronger clays remained as schists to divide the rocks, the lighter conveyed away by the turbid waters, would be so profusely deposited on the rising mountains as to allow the retiring waters to leave the fine shapes of landscape, and the easy curves of rivers in their retreat. All the vallies were once confessedly filled with water, and the rivers are so curved as to give an earlier meeting to a sister stream. These clays, from their weakness, and the solvent action of the atmosphere, unable to form rocks, would give birth to an infinity arenaceous formations designed of providence to form the future loam of the vegetable kingdom.

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* So both Macquer and Berthollet teach, who have successfully directed their experiments to the doctrine of affinities.

In these clays and schists, all the metals, proceeding from their own inscrutable essences, have delighted to concentrate, and sport their formations of veins, lodes, and strata, always leaving much of their essence in the adjacent rocks, or shale; and where the crystallization was too rapid for their escape, they have reluctantly combined with the rock.—The abundant iron ores, a metal most wanted in society, have coated the whole earth with their massive strata.—Platinum and gold, scarce and precious, have formed thin lines of granular ores.—Silver and tin have a striking conformity of veins. One vein of silver at Upsalta, says Molina, is nine feet thick, and extends thirty leagues, from which many branches proceed.—Mercury forms in globular cavities, and often occupies beds of great thickness.—Veins of copper in many places are rich, and thick. Very many kinds of metallic ores will occur in mining districts, contiguous to each other, without the least apparent injury to the quality of one another, each being attracted by its own essence. Gems and crystals prefer the cavities of rocks where they can sport their latent beauties in perfection, pointing from side to side: their figures and tints are always diversified in conformity to the quality of the matrices to which they adhere, or to the fluids which ascend in the fissures. All these ores, except the traverse veins of more recent formation, dip in conformity to the adjacent strata.

Expansion being inseparably connected with crystallization, the elevation of the mountains was a necessary consequence of the crystallization which is the characteristic formation of rocks. This process, acting on the crust of the whole orb, would slightly oblate the hugely massive rocks while yet soft, and the pressure continuing, would throw them upwards into horizontal, oblique, perpendicular, and every possible position. The exuding waters would open in fountains, or collect into subterranean rivers, which in some places are so powerful as freshen the sea for many leagues.

The exsiccation of the huge masses of primitive rocks has caused ranges of caverns to extend through the whole bosom of those high mountain ridges. This circumstance is confirmed to us by earthquakes. At Quito, at Cumana, and in some parts of the West Indies, noises precede and follow each shock resembling the discharge of cannon. The sides and cavities of those fissures are studded and decorated with crystals and gems, whose beauties surpass description, as though nature had ingeniously designed to tempt the bolder miner to carry his lantern to her dark abodes.

The metallic fluids have sported their formations in the schists with which the primitive rocks alternate: whenever they have formed in the rock it seems to have been with reluctance, as appears from the detached masses of ore in cavities. The primitive veins of ore are often richer as they descend, while veins in alluvial earths become extinct. The metals without exception have left a tint behind to colour the rocks. The fluids would also ascend, and repeat formations in traverse veins; aid in the nourishment of vegetables which then adorned the whole face of nature; for in the primitive earth a shale once covered all the present contour cliffs and rugged ridges of those mountains, and loam covered the schistus, until the deluge washed them bare; and in many places so washed their bases, that part of the rock falling on the waves, left a mural and terrific precipice to brave the tempests of future times.

The theory here given of the elevation of the mountains, is copied from a simple occurrence of nature. On seeing one day during winter, a bowl of lard, whose surface was tossed up into ridges of hills, I enquired the cause, and found that the melted fat had been suddenly removed to a current of very cold air in the dairy. The congelation had been so rapid, that the horizontal strata had been broken and elevated to various oblique positions, and many of them made vertical; and some of the vertical had become inclined the opposite way. From the time that I investigated this phenomenon, I abandoned all the old theories of geologists, which suppose continents and mountains to have been elevated by latent heat; because I considered the same law which sported with the strata of the lard, as efficient to sport with the strata of the earth.

But if any calm enquirer after truth shall doubt the correctness of this theory of the speedy formation of rocks, and the consequent elevation of the mountains by expansion, in which the Divine energies must not be overlooked, I would beg leave to refer him to the expansive force of congealed water. It bursts vessels of every description though open. It projects an iron plug driven into a bomb-shell, to the distance of two hundred yards, and if the plug be screwed, the shell bursts with a very destructive force. In the north seas it elevates the peaky heads of ice far above their broad and floating bases.—I would refer him to the great works of art where chrystallization is seen on a still more powerful scale. In the salt-works of Cheshire, the brine, strengthened by the solution of rock-salt, supported by gratings on the surface, is boiled in iron pans, twenty feet by thirty in diameter, and filled with brine to the depth of eight or nine inches; the chrystals, small and detached, profusely fall at the cooler sides of the pan, as the brine becomes strengthened by evaporation. In the yet broader pans, evaporated by solar heats, the chrystals are ten times larger, and more beautiful in figure. I have seen some formed in winter, of two inches in diameter.—I would refer him to the copperas works, established on our hills contiguous to the Yorkshire colieries; for a cold and open air very much augments both the size and quantity of the chrystals. The ferruginous pyrites are exposed, on inclined beds of clay, to the solvent action of the air: the rain-water, secreted from the pyrites, is boiled with old iron for five days in a round leaden vat, fifteen feet diameter, and two and a half deep, until a pint will weigh twenty-eight ounces. The solution is then let off into trays or coolers, wider at the top than the bottom. In three days, the precise time assigned by Moses for the rise of the mountains, the process is completed; and about three tuns of the green sulphat of iron adheres to the bottom and sides of the trays. If a crooked stick be laid across a tray, so as to touch the middle of the liquid, the chrystals adhering to it, are remarkably transparent, and acquire a beautiful perfection of figure.

Latent heats, after the creation, would continue to produce many important changes in the interior of the earth by exsiccation. They would contract the huge masses of rocks, and thereby widen the perpendicular fissures; and one exsiccated rock, acting upon another, would of necessity widen certain places in all mountains into caverns, and open so many mouths to an earth which seemed to breathe. In some places, these caverns would become farther widened by subterraneous fires, and by the slightest convulsions of nature.

The widening of the fissures would open a freer course for the streams, rivulets, and rivers of the subterraneous world. These waters are designated to regulate the temperature of latent heat; to counteract the tendency of calcareous mountains to volcanic efforts; to nourish the whole interior earth, being themselves richly pregnant with every essence of nature; and to repeat all the formations of the first creation of gems, stones, and minerals, in all the cracks and crannies of the deep and vaulted earth.

But while the predominant alkalies thus delighted in all the sparry and chrystalized formations of nature, the predominancy of acids would equally delight to sport in vegetable figures. The dendrites, in gems and marbles, are said by naturalists to be formed metalic oxides; but this cannot take effect without a sufficiency of acids to influence the process, as is apparent from a recent discovery. A potter of Staffordshire, accidentally let fall a few drops of acids on a vase he had just painted. How great was his surprise, on looking again, to see his enamels assume a vegetable figure! Thus, if a drop of mulberry colour, mixed with acid, be let fall obliquely on a pot just dipped in diluted clay, while descending, it forms a tree extremely raminous and beautiful.—The mildew also on cloths, whether linen or woollen, containing soap, at first appears in spots, and then inclines to the form of branches. On very damp walls, plaistered with lime, the acids produce a similar effect. I saw, or thought I saw, on a circular recess, plaistered a fortnight before during a rainy season, landscapes, groves, and retiring graces, too beautiful for the pencil to imitate.—But vegetable fossils in alluvial earths, are mostly the fossils of real vegetables, laid on by deluge.

There is another circumstance respecting the figure of the earth too important to be omitted here. While in a liquid state, it would be formed by its own gravity into a perfect sphere, whose diameter was equal in every place. This is sufficiently evident from the exact bounds in which the ocean is retained. But its centrifugal motion, revolving on its poles; though gentle at first, as the way of a ship when her anchor is just weighed, would incline the sphere to a spheroid, rising at the equator, and oblate at the poles. This is a discovery of the moderns, and first suspected from the slow motion of the pendulum at the equator. An enquiry of the learned followed; very many experiments were made, and numerous theories were advanced. Goods weighed in the north were always lighter at the equator. It was at length determined to measure a degree of the sun's meridian in different parts of the earth. In 1735, the king of France sent Maupertuis to measure it in Lapland, who found the equatorial diameter of the earth to be to the polar, as 179 to 178. But Don Juan, whom the king of Spain deputed to do the same in South America, among the snows of the Andes under the line, found the equatorial to be to the polar as 266 to 262. From the medium of these measurements, it appears, that the earth's diameter at the poles is less than at the equator by $36\frac{948}{1000}$ miles. But Bishop Horsley, taking the mean of seven measurements in different places, finds the equatorial diameter to be only a 340th part greater than the polar. The observations, however, taken in the north, and on the line, are relied upon as the more certain. Now, though the theories are not yet exactly agreed upon by astronomers, yet we cannot sufficiently admire the wisdom and goodness of God in giving the earth this superior elevation, and consequent coolness, in the torrid zones. The motion of the trade-winds, whose breezes give life to the inhabitants of sultry plains, is hereby greatly increased. And it is with the same gracious design of attemperating the heats of a vertical sun, that the all-gracious Creator has caused the highest mountains of the earth to rise within the tropics. Chimboraco, whose base is cut by the equator, rises 21,750 feet above the sea, and Cajamb, distinguished by a double crater, rises 19,480. And both these mountains, being mantled with eternal snow from the elevation of less than fifteen thousand feet, as well as all the higher Andes, revive the western shores of Peru, and cool all the extended shores of the Amazone with torrents of melted snow. The like coolness is attached to the mountains of the moon in Abyssinia, and to those of Thibet in Asia. The cold also of the north and south is much alleviated by the oblate situation of the poles. The Russians continue to assure us that, after passing two or three degrees beyond Nova

Zembla, they find an open sea, unencumbered with islands of ice.

In a word, while the mountains were thus elevating their beauteous ridges, and over-topping the clouds with their peaky heads; and while the extended plains were relieved by the rise of distant hills, the waters, as yet, very turbid, would deposit the aluminous secretions of nature, and gently stratify by undulating waves, the whole surface of the earth. The copious stores of matter so deposited, containing the essence of all created nature, would proceed to repeat on the surface, the interior formations, countless in number, and admirable in structure, while the ever-solvent action of the atmosphere, would counteract the larger concretion of bodies, and prepare the earth to receive her flowery carpet, and become the Eden of beauty, fragrance, and delight.

These outlines of the theory of the primitive earth, in which the author has been guided, as far as his knowledge would reach, by a rigorous adherence to the most assured experiments of chemistry, are, it is presumed with deference, in no wise at dissonance with the Mosaic history of the creation. This man, a senior in philosophy, and scribe of heaven, seems entitled from the habits and circumstances of his life, to higher consideration than what some modern philosophers have been disposed to pay him. His life opens to us in three equal periods, in which he attained the highest excellencies that can adorn a human character. In the first period, while a prince, he became a master in all the sciences and eloquence of Egypt; a nation to whom the Greeks confess their obligations. In the second period, he studied philosophy, and cultivated piety, the best philosophy, in the pastoral retreats of Midian. In the third period, he was constituted the first of lawgivers, and the highest of prophets; and he completed his Divine mission with consummate success.—But his death is more enviable than his life. Having transferred the secular offices to Joshua, he became a model to retiring characters; he gave himself wholly up to his *Deuteronomy*, or recital of the law; he renewed the covenant with all the people;

he closed with the sublimest hymns, and died in full prospect of the promised land!!! This was Moses.—But who—where—what are the men who calumniate his character?

This historian asserts, with a brevity peculiar to early writings, but does not detail the history of the creation. The long-lived sires, fraught with tradition, required but the hints of history. He makes the Creator to begin and finish his work.—"God said, let there be light, and there was light;" and, Hebraically speaking, "the evening and the morning were the first day." This is perfectly coincident with the Newtonian philosophy. Light, from its inconceivable levity, would be the first to escape; would be attracted by the mass of the sun, which, like the earth, was already forming, and give a sort of day and night, though the sun's speculum was not prepared perfectly to reflect it till the fourth day. The atmosphere was cleared, on the second day; but left adorned with the ever-changing forms of beauteous clouds. This also appears analogous to the laws of nature, the air being slower to escape than light. The mountains began to rise on the third; and, though at first naked and bare, yet being fraught with the seeds of all things on their surface, the whole vegetable kingdom presently covered the landscape with verdure. On the fourth day, the surface of the sun became prepared perfectly to receive and reflect the light, emblem of the smiles of God on all his glorious works: and at night, the full-orbed moon prolonged the day, by reflecting back the solar rays. On the fifth day, the waters were peopled with fish, and all the amphibious families, being in a better state of readiness than the land to receive inhabitants. On the sixth day, the beasts, cattle, and creeping animals sprung, if we may credit pagan tradition, from membraneous eggs, to perfection of stature, and found all nature rejoicing at their birth.—Man alone was wanting to complete the glorious work. In his creation, the triune God proceeded by counsel; for man, being distinguished from the brutes, by a moral and a rational soul, was thereby admitted into society and communion with his Maker. "God said, Let us make man in our image, and after our likeness; and let him have dominion." The strength and stature of Adam were proportioned to his duties; his figure was erect; and his countenance was the noblest work of God. He was also endowed with speech, that he might be constituted the priest and oracle of nature, to collect the silent praises of the universe, and offer them up to heaven in sublime hymns, and fervent devotion. The Creator, having appointed the sabbath for repose and worship, rested from his works; but ceased not to be the *primum mobile* in all the successions and productions of the seasons; and in all the latent formations of the earth. He left all nature impressed with his characters, and the mirror of his perfections.

PART SECOND.

THE daring progress of modern mineing has largely acquainted us with the present state of the earth's surface; and, though the penetrations be not more than a ten thousandth part of its diameter, yet they apparently afford *all* that is needful for man to know. The miners are so obstructed in their progress by the abounding of water, and the irruption of noxious airs, that the silver mines at Gottsberg, (the Mount of God,) do not, according to La Pluche, descend above five hundred fathoms; and our tin mines near Camborne, little more than one-third of that depth; and no coal mine is equal in depth to those of tin.

The substance of the knowledge obtained from miners is, that some parts of the mountains and plains are stratified with the repeated action of deluge; but others are not. The former are denominated *alluvial*, and the latter *primitive.* The differences between them are many. The masses in the primitive mountains are larger, and the perpendicular fissures wider than those in the alluvial. Caverns are found in the former, but rarely so in the latter. The primitive mountains are destitute of all animal and vegetable exuviæ; unless partially thrown into their caverns and fissures by inundation; but the alluvial contain petrifactions of all animated nature, shells, vegetables, animals, bones, and sometimes works of art; and occasionally, remains of animals and of vegetables, whose species are allowed to be now extinct *.—Fountains, rivulets, rivers, are found in most mines; and cataracts, and even lakes, in certain recesses of nature. And wherever the miners find a stream of fresh water, it is always accompanied with a reviving current of atmospheric air. In some places, they can descend to considerable depths, and even contiguous to the sea, without being much annoyed with irruptions of water. Beyond where the miners have penetrated, we can have no knowledge of the earth, except from pebbles rolled on the shores, which seem to be strangers washed by the ocean from the deeper surfaces of nature. Some of these contain gems and minerals; and others pave our streets, and seem to authorize a presumption, that rocks, lying deep in the earth, are somewhat harder than those towards the surface. Such are the bowlders at the Spurn Point, or cailloux rouilles of the French geologists: such are the light grey bowlder limestones, washed on shore at the sources of the Ayre and the Wharfe, in Yorkshire, which contain the purest lime of any in this kingdom.

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* Scheuchzer herbarium diluvianum, fol. 9, 10. Kircher has given us a plate, containing four species of fossil dragons, having two feet each, and of the amphibious class, which had been dug out of the mines, and were preserved in the Museum of Cardinal Berrinus.

Subter. Mund. tom. ii. lib. viii.

With regard to subterraneous rivers, many of them are so powerful as to freshen the waters of the sea, which is the only circumstance by which some of them have been discovered. Charybdis issues with a very powerful current from the rock at the bottom of the sea, near the city of Messina. This discovery was made by Nicholas Peche, who descended after a golden cup. It excites a considerable swell in the water during the calmest weather; but being gradually curved by the more powerful current of the Straits, it forms an eddy of a hundred fathoms in diameter, which gently carries a ship round, without doing her further harm. Kircher, by a plate, represents it as coming from Africa; but the smaller river, to the south of Messina, does not appear, as he supposes, to be a branch of Charybdis, because it is often boisterous when Charybdis is more calm. This whirlpool, being opposite Scylla, a dangerous rocky promontory, on the Italian shore, furnished proverbs to the people, and figures to the poets. They said, " He that would avoid Scylla runs into the vortex of Charybdis;" and again: " He that would avoid Charybdis falls on Scylla." In Virgil's description, or imitation of Homer, we have a stretch of the hyperbole:

"Dextrum Scylla latus, lævum implacata Charybdis
Obsidet: atque imo barathri ter gurgite vastos
Sorbet in abruptum fluctus, rursusque sub auras
Erigit alternos, et sidera verberat unda."

"Far on the right, her dogs foul Scylla hides;
Charybdis roaring on the left presides,
And in her greedy whirlpool sucks the tides,
Then spouts them from below; with fury driv'n,
The waves mount up, and wash the face of heaven."
DRYDEN.

Before entering on the changes induced on the earth by deluge, it is proper to meet an objection made by some geologists, against the Mosaic history from the marble tablets, which, in many instances, exhibit broken shells, and fossil-teeth, evidently worn with mastication. To this it is replied, *first*, that testaceous marbles are never found at any great distance from the present level of the sea. *Secondly*, That from the creation to the deluge, the sea, as now, would make war on promontories, and deposit her erosions on calmer shores. *Thirdly*, That the shells so covered in places where the under strata were disposed to promote the formation of marbles, by the ascension of the marmorous fluid, would unite with the matter so laid on, and concrete into the beauteous masses in which they are now found. Consequently the Noble Author of *the beauties of Christianity*, seems injudicious in the ascription of a mutilated and imperfect work to the all-perfect Being. "The very day," he says, "that the ocean poured forth his first waves, he doubtless laved rocks already worn by billows, shores strewed with fragments of shell-fish, roaring gulphs and naked cliffs, which protected the sinking coasts against the ravages of the waters *."

In other places, the turbid deposits of the sea, containing salts, magnesia, and marine acid, holding a considerable quantity of minerals in a state of solution, would, attracted by the combining and concreting essence of the under strata, repeat all the other formations of primitive nature, though in smaller masses. To these must be added, the lava, which in other places was rolled on the vallies by volcanoes, and the bursting of mountains, where the sea had a rapid access to their latent fires. These considerations respecting the state of the antideluvian earth may prompt us to speak with deference of many formations for which we are unable to account.

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* Count Chateaubriand, translated by Shoberl, book iii. chap. v. He is an excellent writer, and judicious traveller.

In making here but *two* divisions of the earth, the primitive and the flood-washed hills and plains, a deviation is made from most of the modern theories, which generally give us *four*, besides the effects of volcanos, and the daily changes made by estuaries or tides of the sea. These are 1. The primitive rocks, which have a sharply defined and rugged appearance. 2. The transition, which are more obtuse in figure. 3. The floetz or flat and stratified, as described page 62. And 4. the alluvial, said to cover the greatest part of the earth with clays, sands, coal, bones, and shells. "Transition rocks are supposed (by Werner) to have been formed while the earth was passing from a chaotic to a habitable state."—*Jameson's Mineralogy, vol.* iii, *page* 145. As these transition rocks contain confessedly shells which appear to have attained the age of forty or fifty years, and coralties which might have been forming a thousand before, a difficulty arises in admitting that the All-Perfect Being needed so much time to complete the finish of the second coating of the earth. And how could either aquatic or gramineous animals attain that age before the earth, and consequently the sea, was habitable? The floetz rocks also are often filled with beach-worn pebbles, sands, and sometimes with works of art, as the coin, and the brass pin found in flint mentioned by Kirwan in his Geological Essays. These are confessedly difficulties in the divisions affected by many geologists. All theories not strictly founded on nature, not only embarrass and misguide the pupil seeking truth, but even the most learned of geological travellers. Professor Pallas left Europe with an idea that rocks were of three orders,—primitive, schistose, and horizontal. But in the Crimea, when examining the high ridge of mount Tauride, he found in the whole chain nothing but secondary rocks, having a dip of forty-five degrees towards the south-west, and north-west. Humboldt corrected himself in other errors of like nature. Professor D' Arcet found himself misguided by other parts of those theories, as related page 81 and 85. D'Aubisson found organic remains in mountains in the vicinity of Mont Blanc, which had been considered as primary. *Journal des Mines, an.* 1812. Our compact mountain limestone ranges have been considered as transition rocks by a sort of a general consent, and as agreeing with the characters of the Wernerian, which are allowed to "contain corals and zoophites, according to Professor Thompson, which no longer exist." We shall come at the whole truth by degrees. Professor Jameson says, "They contain corallites, encrinites, pentacrinites, entrochites, and trochites." vol. iii. 145, 146. I agree with those gentlemen. After personally examining the transition rocks at Castleton in Derbyshire, and the huge masses of grey-coloured limestone of Lancashire, and those of Settle in Yorkshire, I do assure the reader that they contain shells of innumerable species, and lying in detached confusion as the wreck of impetuous waters. And I am of opinion further, that one sixth part of those shells agree in character with recent ones, as Professor Cuvier has ingenuously admitted with regard to eleven of the sixty fossil shells which he examined. But allow me to ask, What age the vastly extended coral reefs might be from which these fragments were detached? Moses frankly answers, 1656 years. Is not the chronology of Moses well supported by the appearances of nature? Could insects which are very minute form vast reefs of rocks in a less space of time? Am I then to believe the Wernerians, that the All-perfect Being needed millions of years to complete the first coating of the primitive world? Am I to believe them against millions of the dead who rise from their fossil tombs to refute the absurdity of this novel theory?

We now enter on the consideration of the desolations, changes, and new formations which the universal deluge effectuated on the surface and the upper strata of the earth.

Of the event itself, we are assured beyond the possibility of a doubt. We have no difficulty in proving it, except from a superabundance of proof. It is asserted, both by sacred and prophane historians, how disguised and disfigured soever the latter accounts may be. Plutarch, in his book on the industry of animals, mentions both the ark and the dove. The account Ovid has given of the flood, in the reign of a king surnamed Deucalion, which drowned all Thessalia, and from which the king and his wife were saved on Mount Parnassus, seems to be a confused tradition between the deluge of Noah, and a partial inundation, which shall be noticed in order. The etymology of the name Deucalion, from Δευτερος *the second,* and καλεω *to call,* fairly imports the recalling of society a second time into existence under the patriarch Noah. It was usual with ancient nations to give new names to princes, expressive of auspicious events; a custom not yet wholly discontinued. The landing of Deucalion on Mount Parnassus, it would seem, is but a confusion of tradition concerning the resting of the ark on Mount Ararat. The deluge not only covered both these mountains, but has left stratifications on all the higher mountains, as far as the snow will allow us to ascend. In Switzerland, Count de Saussure asserts, that marine petrifactions are not found higher than 2,800 feet, (equivalent to about 3,000 English feet,) above the level of the sea, and in caverns sometimes to the depth of twelve hundred feet; yet there the summits of the hills exhibit the desolations of the waters in characters which command universal assent.

The moral cause of this unexampled catastrophe is wholly attributed by the Hebrew historian to the great and incorrigible wickedness of the antediluvians. And what could be more assortable to the Divine perfections, when the apostacy was total; when all flesh had corrupted its way; when the sons of the great seized the daughters of the poor; when the earth was filled with violence: when the prophesying and translation of Enoch had no effect; when the preaching of Noah, and the building of the ark excited scoffing rather than reformation; what, I say, could be more assortable to the perfections of God, than to save the one righteous family, and wash away the filthy inhabitants of the earth?

The physical cause is attributed by Dr. Halley, and two or three other astronomers, to the near approach of a comet towards the earth, which, Mr. Whiston thinks, descended on the plane of the ecliptic. To these suppositions real difficulties may be opposed which seem insuperable.— Why has not the same comet returned, and often returned in so great a lapse of time? Why are the strata of alluvial earth found too numerous to agree with the number of tides which could take place during the short time that the earth could remain in the neighbourhood of a comet? Nor should it escape remark, that a man, who calmly investigates the bounds prescribed to the ocean, and the precision of gravity in the flux and reflux of the sea, can never be brought to believe that the prodigious tides which ravaged the old world could be attracted to overflow the hills without a special command from the God of nature.

The elder Rabbins, mostly followed by the Christian fathers, commenting on those words of Moses, "The fountains of the great deep were broken up," suppose an irruption of latent waters, which covered the earth's surface to the elevation of the mountains. But such an elevation, instead of stratifying the earth, as we now find it, would only harden its surface by an immense pressure. When a spring tide retires, we every where find the sands so closed by the pressure of not more than forty feet of water, as scarcely to be indented by the gallopping of a horse. Consequently, the flux and reflux of prodigious tides, seem the only theory on which the students of nature can account for the stratification of the earth. And, as the moon now governs the variation of the tides, were it lawful to indulge in conjecture, I should think, that God, who employs means the most natural and easy, was pleased to drown the world by an increase of elipticity in her orbit.

The Mosaic history of the deluge has been carefully examined by Dr. John Lightfoot, who equalled the rabbins in Hebrew literature. The whole period, according to him, comprised a solar year. Forty-six days of this period were spent in conveying stores and provisions for the ark; and seven in receiving the beasts and cattle. The rain began to fall on the 18th day of the Hebrew month of Marchesvan, which coincides with part of our November, and continued forty days. During the fall of the rain, it is thought that the atmosphere was much darkened, because it was afterwards promised that day and night should no more cease, Gen. viii. 22. The waters or tides continued to increase for one hundred and fifty days. The decrease commenced on the first day of Sivan, which coincides with part of our May; and continued one hundred and twenty days. Thus we trace the counsel of heaven, and not the accidental approach of a comet, in allowing Noah time to reap the harvest before the rain; and in bringing him out of the ark at a season proper for following the waters with the seeds for the succeeding year.

The changes and ravages of nature, correspond with the impetuous force of the flood. Travellers and geologists are all agreed, that, in every continent and island, the mountains, hills, and declivities, are, in places without number, left desolated of earth, craggy and bare; and many of the rocks of bolder hills, and salient promontories, appear to have been detached to a considerable distance from the elevated summits to which they once belonged. Against promontories and bolder shores, the flux and reflux of the tides would be so impetuous, as, in many places, to undermine their base, and the part so undermined, would fall prostrate into the sea, leaving the side from which it was disjoined by caverns and fissures, a mural and terrific precipice, to brave through future ages the incessant war of the ocean. M. de Saussure has described the precipice of the calcareous rocks of Mont Brezon, in Switzerland, as the most sublime and terrific he had ever seen; and he traced the action of water 200 toises higher than the lake of Geneva. Bishop Pontoppedon tells us, in his history of Norway, that the water close to the rocks is generally three or four hundred fathoms deep. In Floge Creek, he adds, no bottom can be found with a line of a thousand fathoms. Nordall Creek is reported to be nine hundred fathoms in depth; and other Creeks of Norway, which indent themselves ten leagues within the land, continue to have three or four hundred fathoms of water. The bottoms also of those creeks resemble the land in hills, dales, and rugged rocks.—Several of our English navigators give us similar accounts of creeks in the western coast of North America, and in the vicinity of Nootka Sound. How tremendous must be the idea of the deluge descending from promontories so elevated! How profound must be the guymes and abysses they would work by the impetuosity of their cataracts! But it is also to be remarked, that all these contour and daring cliffs have remained much the same since the deluge; the seas, as is evident from topographical history, have made few advances, except against the promontories and shores composed of softer earths.

It is therefore apparent, that whatever earths the impetuous tides of the deluge washed from one place, they must of necessity deposit in another. This is an invariable law of the ocean. Hence one tide would bring gravel and marine exuviæ, already worn by the action of the billows rolling on the shore; another would bring sand, and a third clay. But though all alluvial strata were formed of the detritus of the old earths, they would repeat the first formation by combination. They would change into a variety of silica, rocks, marls, and minerals; while others, falling on more neutral earths, would remain in their primitive state. Thus also the deeper strata of the earth would be laid on while the waters were rising; and all the more loamy earths, by the gradual retreat and subsiding of the waters. These long continued actions and deposits of the water are a sure guide in accounting for all the conformations and heterogeneous masses found in most parts of the alluvial earth.

This idea, that the deeper alluvial strata were laid on by the increasing tides, assists us to account for the deposit of coals; a subject which is here presented to the reader from the actual study of nature, rather than the perusal of books. Coal is confessedly a vegetable fossil; and, from the purity of its beds, we have the justest grounds of conclusion, that it once floated upon the sea. When analyzed, charcoal constitutes the principal part of its base. Acidulous waters, bitumen, and hydrogen, it contains in various proportions. Its combustible qualities, and its ashes, may also be retraced to a vegetable origin. Both the bovey coal, and the coal which swiftly burns to white ashes, exhibit the fibres of wood. The argilla, and the animal substances, of necessity mixed in the mass, have been very much converted into its own essence, as is usual in other combinations of nature. Its colour is derived from iron, which it powerfully attracts; and no one could doubt of this, if he would consider the quantity of iron contained in all vegetables, or how powerfully this mineral changes vegetable dyes to black. The various families of coal, whether of jet, common, or cannele, seem to derive their distinction from the different kinds of timber, and from contiguous earths; but the more bituminous, obviously participate of a larger quantity of animal substances, which would also float on the waters.

These floating masses of timber, eradicated by the deluge, and locked by the roots and branches, and much increased by vegetables, as well from the sea as the land, were assuredly laid on by retiring tides in those calmer bosoms of the earth, where the sea was disposed to make her deposits. This is demonstrated from the stratification of the earth above and below the coal; and from works of art being occasionally found in the mass. Pennant reports, that the ancient Welsh found a flint axe in the midst of a bed of coal. It is not questioned but the axe had been lodged in a tree, and floated there by the ocean. In all places where the under stratum is horizontal, the coal is horizontal; and where it is inclined, as is mostly the case, the coal is inclined; but where it is rugged with rocks, the coal participates of the inequalities, being broken into gauls. In such places, the miner suddenly loses his bed; which, however, he finds again on working round.

But coal, it will be said, often lies deep, and far below the level of the sea; and, that whatever weeds the tide may leave in bays, they are raised again by the next tide, and mostly carried away. Near Newcastle-upon-Tyne, the Montague main colliery is more than one hundred and twenty fathoms from the surface, and covered with ninety-three strata. The Low Main coal, at St. Anthony's, is one hundred and thirty fathoms deep, and covered with seventy-four strata. The Staffordshire coal lies on a greater declivity, and nearer the surface. How deep the coal descends is unknown; for the pits are not worked deeper than seventy fathoms.

All these considerations may be regarded as difficulties rather than objections. In studying the situation of the

Staffordshire coal, the following solution presented itself, which, to me, appears satisfactory. *First*, that the vast flotilla of vegetables and timber, being completely locked, roots and branches, by the undulations of the sea, would be deposited on the soft surface left by the preceding tide. *Secondly*, that the various heath plants, which contain more iron than any other, with all other kinds of vegetable, and often animal substances, would so sink downward among the bodies of the trees, as to form one mass, and greatly press the roots and branches into the soft earth. Consequently, the next tide, recoiling with indescribable impetuosity, and being as turbid as the water could bear, could not possibly raise the vegetable mass locked in itself, and now adhering to the earth, until the waters were considerably advanced on a shore, which dipped one yard every fourth, as is here the case: meanwhile, the turbid matter, among the calm, produced by the roots and branches, would make so rapid a deposit, that before the waters were high enough to raise the flotilla, the mass, under these circumstances, would, almost instantly, become completely entombed by an incumbent stratum. The next tide would lay a second stratum: and every third, fourth, or fifth tide, seems to have brought a new flotilla of timber, and left it in the western bosom of the mountain, which has become entombed, and stratified as the former. In this manner, so far as the tremendous operations of the deluge can be traced, in the short space of two leagues, fifty or sixty beds of coal were laid on between Burslem and Mowcop, as immense treasures for future times. The number of strata between each bed, apparently indicates the number of tides which rolled against this primitive mountain, between the arrival of each flotilla. On the eastern declivity of this mountain, where the Trent has its source, the coal dipps the opposite way, varying in all places, according to the flood-washed shores on which the timber was deposed.—How weak then must be the argument of Mr. Kirwan, that bovey coal is coeval with the creation, because calcareous rocks also contain 27 parts of a 100 of carbon. No doubt, all the families of coal, deficient of carbon, and very slaty, are largely mixed with the turbid deposits of the deluge.

Our attention must next be directed to the formations of nature, in the alluvial or newly stratified earth; in which all the laws of affinity and attraction would act with full effect. It is, however, to be remarked, that much of the matter laid on by the deluge, as rocks, flint, and minerals, being already formed, are the detritus of former strata, not liable to change. Yet the heterogeneous masses would produce an immensity of formations, by the conflict of their component parts. These, though weaker in the resources of energy, than at the first creation, would be the same in operation. The waters oozing through every strata, would form their subterraneous currents, and the atmospheric air, every where attendant on those currents, would aid the chrystalizations of the earth. Every essence of nature would collect and concrete in the struggle. The whole alluvial masses would therefore change in colour, change in quality, change in character, and diversify in species. The silica would granulate in all dimensions, and assume their tints, as in the first creations; the more calcareous masses would concrete into the various species of limestone; while the more neutralized alumine would vary its colours and qualities, as it participated of surrounding substances.—The whole would then, by the expansion of latent heat, and the diminution of moisture, break by fissures into masses, as they now are found to exist.

This subject, respecting the concretion of earths and minerals, requires to be distinctly resumed, that we may trace the laws and operations of nature with the certainty of experience. It should here be remarked, that though mineralogy, taking the word in the most extended sense, has been cultivated with great care for the last two centuries; yet the authors widely differ in their classifications. The Germans, prompted by their numerous mines, were the first to cultivate the science. The dream of obtaining gold from earths and metallic substances, created many laboratories, and made discoveries of great value, until Erasmus satirized the visionary pursuit in his dialogue, entitled, *Alcumistica*. Keatman published in 1663, and was followed by others. Kircher, a priest, in two folio volumes, called *Mundus Subterraneous*, accompanied with numerous plates, gave the public a synopsis of what was known to the Germans and Italians. In 1708, Becher's work appeared, in which all metals that would bear the hammer were denominated perfect, and all that were not malleable were denominated imperfect. In 1739, Sir Charles Linne's work appeared; and his studies being favoured by a contiguity to the Swedish mines, he has endeavoured in mineralogy, as in botany, to relieve the science of the different names given to the same substance. But Cronsted's work, for the time, bore away the palm. He makes four grand divisions of the mineral kingdom;—earths, comprising rocks;—salts;—inflammables;—metallic ores. This work, re-published with Magellan's notes, Sir Ashton Lever made the guide of the classifications of his cabinet of mineral fossils. Sir Hans Sloane expended £50,000 in procuring a similar collection, which Parliament purchased, and made the basis of the cabinet in the British Museum.

The relation which geology bears to chemistry and mineralogy, is that of a parent to her daughters. Geology examines the concretion and situation of all substances contained in the earth; chemistry discovers their internal properties by decomposition and combination; and mineralogy describes their external characters. Since the analyses of chemistry in the humid way, have been brought to a very high degree of perfection, by Scheele, by Bergman, by Klaproth, and others, a renovation has taken place in the classifications of mineralogy, and in the application of more appropriate terms. It is an almost new-created science. Werner, in 1774, gave a system to the world, which is now generally followed by scientific men, and confessedly, by our industrious Kirwan. He describes the external characters by their colour, shape, lustre, transparency, texture, cohesion, density, adhesion, feel, and fracture. The classifications are by genus;—species;—family; variety, &c. The analyses of the ores, and the descriptions of their exterior appearance are conducted with all the accuracy that genius, literature, and experience can confer upon the subject. The three associate sciences have conferred the highest obligations on agriculture, on medicine, and on all the arts.

Ores of iron seem to have a first claim on our notice, because nature affords them in the greatest abundance, and with a few exceptions, all other ores are mixed with them, in a greater or a less degree. On examining the situation of the ore on the shelf-mines of Messrs. Hayden and Elwell, near Bradford, I found the principal stratum four feet above the coal, formed in a loamy earth, in horizontal parallels with the coal. The thickness is about five inches; and four feet above it is a second stratum, two inches thick; and two feet higher a third stratum, one inch thick; and a little higher, I perceived a fourth, not thicker than my finger. What an extraordinary law and sport of nature! What a demonstration that the ferruginous fluid had ascended in the alluvial earth, and weakened itself by each successive formation in its ascension towards the surface, to nourish the vegetable kingdom; and especially the heath plants of those hills, which contain abundance of iron!

The figure of the ores is massive, from one pound to half a hundred in weight. They are nodular, ovallar, tabular, and some specimens occur botryoidal, and amorphous. The larger ones are hollow in the middle, in which four-sided white chrystals are always formed. In colour, the Yorkshire ores have a gradation of shades from the black brown to the dark red, and thence to the pale blue, and sometimes inclined to the yellow ochre.—Animal and vegetable fossils also occur in the ores of various kinds. Bamboo cane is very abundant. I was presented with a riving of oak, so coated with the ore, as to preserve the fibres perfect; with the upper end of a femoris, apparently fractured to obtain the marrow; with a fir-apple, as large as a child's head, of which many are found. In a word, whatever earths, vegetable or animal substances, were found in the stratum, which the ferruginous fluid chose to occupy, it has converted into its own essence. The iron ores below the coal, in the above mines, are formed in a diminishing gradation of strata, as those above.

I examined the iron ores also at Golden-hill, where the Grand Junction Canal has a tunnel through the mountain, and found their situation much the same as in Yorkshire. But the nodules are often larger, and more inclined in colour to a bluish clay. The colours of ores in general are found to participate of the earths and matrices in which they form.

The well-sinkers in Lincolnshire and the vicinity of Howden, often find a stratum of stones, which they call *Osmund's*, from Mount Osmund, in Sweden, which abounds in iron ores. Osmundic earth also derives its name from the same mount. Henry Bell, Esquire, of Estrington, took me to see a small heap, which his plough had discovered in a field. I am of opinion that they had been found in digging a well, and deposited there; and no well is deep in that neighbourhood. In colour, they declined from a dark red to an iron grey. In figure, they were nodular, ovallar, reniformed, and some of them had protuberances resembling the half-fingers of a man's hand. I was further of opinion, that they contained above forty per cent of iron, and were much more free from sulphur than coal ores; and, consequently, a *desideratum* for making edge-tools. Bergman mentions white ores of iron found in Sweden, Germany, France, and Spain; and called *Stahlstein*, or *Stahlertz*, by the Germans, because the metal contained in them can be manufactured into the best steel.

Pyrites, (πυριτης, fire-stones or crackers,) are ferruginous minerals, saturated with sulphur, vitriol, &c. and may properly be classed among martial ores. In colour, they are more inclined to a grey, and to bluish clay than the iron ores. In figure, they are found nodular, ovallar, reniformed, and disseminated. The mundic or copper pyrites of Cornwall approach in colour to the yellow gold; and are found sometimes massive in cubes, but mostly disseminated on a matrix. The white pyrites receive their colour from arsenic, and require considerable time to dissolve in the open air. They are found also in chalk, and in most other earths.

Respecting the very extensive bed of pyrites in the Birching wood-pit, near the Grand Junction tunnel, I noted down the following particulars, from Joshua Hancock, who sunk the pit. Sixty feet below the surface, he found the three-feet-bed of coal; and thirty feet below, the Rider-bed, consisting of slaggy coal, five feet thick; but the three upper feet are better than the two lower. Eight feet below the Rider, is a third bed of defective coal, four feet thick. Six feet lower occurs the Ragman-bed, the best and thickest in all the mine. At a further depth of forty-eight feet, is a fifth bed of good coal, seven feet thick. Sixty feet lower, and about two hundred and eight feet from the surface is the pyrite-bed of coal, eighty feet thick, and not much inferior to the Ragman. In this bed, occurs a phenomenon of great interest to the students of nature. In the midst of this coal, the pyritous fluid has concreted to the thickness of two feet. The incumbent coal is two feet and a half thick, and the nether stratum five and a half: of course, the coal was originally ten feet thick. But they do not work the nether coal, the pyrites being so indurated, that thirty pounds of gunpowder were expended in penetrating through the strata. In colour, they are more brassy and yellow than other martial pyrites; and in figure, those I procured, are much diversified. Eighty-one feet below the pyrite-bed, is another ten-feet bed of swift burning coal, whose ashes resemble those of fir-timber. How extraordinary is the law of this pyritous fluid, that out of seven very rich beds of coal, all as yet penetrated to, it should concrete in the sixth, and convert the coal into its own essence, and completely change its colour, figure, and qualities! And were it not for these providential concretions, the coal could not be burnt in our houses, the effluvia of ignited pyrites being peculiarly destructive to the lungs. But, after ascertaining these, and innumerable facts of a similar nature, how is it possible to receive the notion of some geologists, that "All our mineral strata, beginning with granite, have been produced by chemical precipitations, from liquids which had originally encompassed our globe!!!" How could an element, so uniform in qualities as the sea, make precipitations so diversified!

The magnet ought also to be classed among martial ores, iron being the principal proportion of its composition. It is dark, or almost black in colour; but few of its properties are known, except its powerful attraction of iron, or of any other mineral participating of ferruginous qualities.

With regard to the richer ores of the mineral kingdom, it may be a disputed subject, whether the botanist, who exults in tracing the beauty and variety of his flowers, can have any advantage over him who investigates the more latent and permanent beauties of nature. The student, who calmly examines the private and public cabinets of ores and fossils, on a liberal scale, can have no difficulty in acceding to this opinion. All we can do here, is merely to name a few, and refer the reader to the works already named.

Platinum, the heaviest of metals, forms itself in thin strata, from the sixteenth to the eighth of an inch in thickness; is exsiccated into regular cubes, and never adheres to its matrix. It contains considerable alloys of osmium, iridium, and of iron.

Gold, like platinum, is formed in thin strata; but its cubes are worn with friction at the bottom of rivers. Gold also is found adhering to a matrix of quartz, and other rocks and earths, sometimes crystallized, sometimes foliated, and sometimes interspersed. It is very generally diffused through all nature, though in small proportions, as in sands, clays, and pyrites. In the British Museum is a beautiful specimen of native gold adhering to its matrix.

Ores of silver often resemble ores of tin. Sometimes they contain native silver in masses, or granulated. Sometimes the ore is laminated, and in other specimens tessalated; and often associated with ores of gold, copper, and lead, adhering to the same matrix. It is this variety of minerals and alloys which diversifies the colours, and figures, and multiplies the beauties of the ores we see exhibited in well-selected cabinets.

Ores of mercury are distinguishable from all others by the fluidity of the metal, which lies disseminated through the matrix in an infinity of small globules. In some mines, these globules have descended into the cavity of a rock, where the miners have but to put it into bottles; but in all other instances, the ore is distilled, and the mercury carried up in transparent fumes, which are collected in water. In colour, the cinnabar ores are red; some are hepatic; and sometimes native vermillion occurs.

The Copper ores are among the most beautiful of the whole mineral kingdom; but the beauty of many specimens in cabinets is much impaired by long exposure to the air. They decorate the chimney-piece of almost every miner in Cornwall, and in Wales. Sir Ashton Lever collected one hundred and fifty specimens; the British Museum exhibits specimens selected with equal judgment. The taste of the Swedes, the Germans, and Russians, is similar to that of the English, it being a sentiment of human nature to admire productions of nature, so various in figure, and exquisite in beauty. In colour, they descend from the black brown to the Madona, and the finest shades; and diversify their crystals according to the proportion of salts and pyritous sulphurs with which they are combined, and to the matrix of quartz, crystals, shorl, or mica, in which they are formed. The waters also which descend through the veins of copper ore, have the singular property to seize all the particles of sheet-iron, and convert the whole into real copper; but of a nature more brittle than the sheets rolled from the pure metal.

Tin ores are mostly of a dark dull colour; but their lustre is great as reflectors. The veins, when cut by the strokes of the workmen, reflect the light of the lamp with remarkable brilliancy. The fractures are mostly lamillar, or minutely conchoidal; and the crystals exhibit a variety of tints and figures. The wood-tin, found only in small pieces in several mines near St. Austle, I am fully satisfied, was, as the wood in iron ores, once real timber, seized by the fluid, and converted into tin, because of the exactness of the fibres, and because of the iron in those ores, which is inseparable from timber. The stream-tin consists of particules of tin washed from the mountains into the streams; but especially of particules washed from pulverized ores, and become increased and concreted into polygonal figures, often approaching the cube, but mostly octohedral, and sometimes quadrangular pyramids. They are too large and too numerous to have escaped the careful notice of the workmen.

The situation of the tin and copper ores, is a subject of the greatest interest to the geological student. The loads of the mines in St. Just, extend into the sea: and I have no doubt of their extending under it to the Isle of Anglesea. Were I allowed to transport myself to a favourite spot in my earlier years, I would say, that a lover of nature might stand among the once hallowed granite blocks of *Cairn Brae*, and see both the seas, and looking northward to St. Agness, and westward towards the Land's-end, most of the mining district in Cornwall west, would be commanded at a view. He would see a grand chain of *wheals* or mines, ancient and productive, in which myriads of his fellow-creatures are burrowed, sometimes to the depth of two hundred fathoms; and sometimes penetrating under the sea, till in tempests they can hear its surges break above their heads!

On descending those mines, and on obliquely penetrating their shafts, he would find the granite strata, which raise their rugged heads on the hills, and guard the coasts, descending in the same strata, but softened from the surface with kellas or schistus, and the schistus sometimes separated with thin veins of ochre, tinted yellow by oxygenated iron. In some places he would find those grand pillars considerably curved, which coincides with the opinion already laid down, concerning the curdled masses in the first creation, and of the consequent flattened strata, and frequent curvatures, by the irregular pressure of the crystallization. He would perceive also how these strata had been elevated often into vertical and all other possible positions; a law of nature, which has operated on the whole surface of the earth. He would find the rich load of tin, often twenty inches thick, lying parallel with the granite strata, and rising from depths unknown, till the ploughshare discovers its existence. He would find also many small branches of the load extending, till gradually lost in the schistus and the spar. In some mines, and at no great distance from the load of tin, he would find a load of copper ore, equal in thickness to that of the tin. And, strong as the granite pillars are, he would, in certain places, find them fractured, with a subsidence, and a vein of copper or of tin formed in the fracture; which loads unquestionably are of juvenile birth, compared with those in the primordial rocks. He would find, both in the sides of fissures, and in the fractured rocks, decorations of crystals and of ores, variegated in colour, and diversified in figure, consonant to the richest sports of nature. In a word, he would sometimes find ores of most other metals, limpid streams, ever-making formations of quartz and spar of beauteous white, and no where be exposed to the carburretted hydrogen, at once terrific and destructive in most of our collieries.

The ores of Lead contain a peculiar variety of figure, and of fracture; but are not distinguished with equal variety of colour, as those of copper and tin, except when mixed with other minerals. The ores, denominated galena, consist of lead largely alloyed with sulphur. In colour, they often approach the green, the yellow, and the brown.

The ores of nickel, zinc, (comprising calmine and blend) antimony, bismuth, tellurim, arsenic, cobalt, manganese, tungstein, molybdenum, uranium, titanium, chromium, columbium, and tantalium, form, by their peculiar laws, and possess, great variety of colour and beauty, as well as of figure.

From minerals, our next transition is to the alluvial rocks, which have every where formed themselves in the stratified earth, to the great advantage of society. These being composed of sands, crystals, minerals, clays, and rocks, first concreted after creation, are but secondary formations; and consequently never pure; and mostly less hard than the primitive. The exsiccated fissures also are more numerous and less wide. The colours, it would seem, have suffered some impairs of liveliness and beauty.

I would here repeat a general principle, that the genera, the species, the families, and varieties of rocks and concretions in the alluvial earth, have proceeded from the variety of deposits warped on by the far rolling tides of the deluge; and that their concretions have proceeded, not only from the changes induced by internal affinities, but chiefly from the ascension of primitive fluids, which would spontaneously repeat, though in a weaker degree, all the formations of primitive nature.

Lime-stone, comprising every species of calcareous earths, has the first claim of notice, from its abundance. In colour, it participates of all the clays, marls, and minerals, which enter into its composition. On the Lancashire hills, it is dark grey, proceeding from thin coatings of black, which lie between the crystals. The Ferrybridge lime-stone is of a dull willow colour; and that of Mendip-hills is red, variegated with blue, yellow, brown, and flesh-colour.

Lime-stones are classed in species and families: the arenaceous; the silicious, of which many families, Mr. Anderson says, occur in the vicinity of Sunderland; the testaceous, as in marine-shells; and stalactites. The calcareous marls may also be regarded as wanting only an increase of silica to concrete them into lime-stones.

The Portland-stone, as all other free-stones, is among the local formations of the alluvial earth. In colour, it is whitish, obviously from its vicinity to the chalk; and, in hardness, it improves by exposure to the air. St. Paul's cathedral, and the Mansion-house of London, are proofs of its durability. The Bath-stone, when quarried, is remarkably soft; but with exsiccation it becomes indurated. The calcareous marls have given it a beautiful basket yellow; and in gravity, it slightly exceeds the Portland free-stone. The stone which occurs in the direction of Doncaster and Thorp Arch, in Yorkshire, participates of a middle colour between the Portland and the Bath stone; and the three are nearly equal in gravity, and in the quantity of calcareous earths which they contain. But the stone, laid on the brows of the hills west of Leeds, by deluge, surpasses all others in England, for beauty and durability. In colour, it approaches the Bath stone; but is often variegated with red calces of iron, or the bluish tints of clay. The upper part of the quarries contain flags, used for the walking-paths of London, and many other towns, and slates for houses. But each of these four varieties of stone, lying towards the top of the quarries where the concreting fluid is weakened, are apt to decay by exposure to the air. The side of Lelant church, next to the sea, I perceived, had decayed about one inch, half way up the tower, as indicated by the lime, which had retained the figure of its first cement.

Granite rocks, which compose chiefly the great pillars of mountains and continents, occur in the alluvial, as in the primitive earth. They differ widely in colour and character, according to the rhombic quartz, the feldspar, the tinted shorl, the steatites, the hornblende, the basalts, the garnet, the mica, &c. which, in different places, enter into their composition. The grey-coloured granite of Scotland, is so indurated, as to be employed in London and great towns for paving the streets. These rocks are primitive productions. Those of Scilly and Cornwall are softer in quality. Of sand-stones, we have many varieties; primitive and alluvial. In colour, they are yellowish, grey, tinted with oxides of iron, or with veins of red oxide; but others are of a darkish red. They readily pulverize, and become very white when calcined. These araneous concretions sometimes comprise quartz, flint, hornstone, feldspar, &c. Sometimes calcareous, sometimes silicious, and sometimes argillaceous qualities, predominate in their concretions; and when highly indurated, they make mill-stones. It is for want of those qualities that many strata of sands cannot concrete, though pressed by the superincumbent strata, so as to have the appearance of rocks.

The chalk rocks, extending from the south east of England, to a considerable distance in the north of France, afford a beautiful variety in the stratification of the earth. They are apparently among the latest deposits of the deluge. The chalk, south of Dartford, as in other places, contains vegetable impressions, and marine shells. In colour, lustre, and hardness, the varieties of chalk correspond with the varieties of lime-stone; and this correspondence is confirmed by analysis. Of a hundred parts, Vauquelin found 53 lime; 42 carbonic acid; three water; and two alumine. Kirwan has adopted this analysis. Consequently, they are lime-stone in some degree neutralized by a superabundance of fixed air.. If, after calmly contemplating many varieties in this calcareous family, geologists will allow me to hazard an opinion as to the change of lime to chalk, it should be, that of the ascension of a fluoric acid, which has seized and decomposed the silica in the lime-stone, and concreted it again at the almost equidistances of three and four feet. The indurated qualities of the rock being thus destroyed, it is left soft, and is rapidly wasted by the undulations of the sea. The ferruginous fluid also, being hereby set more at liberty, has ascended to the incumbent strata of marls, and very much reddened their tints. The siliceous fluids have also ascended among these marls, and concreted in gem-coloured flints, ovallar and amorphous in figure.

The genus of silica comprises its species and families, and varieties of flints or gems, which cannot be counted. Flints in the chalk are black, dark grey, and spotted with white, when less pure. They are semi-transparent; and often highly so. In figure, nodular, portuberose, amorphous. When calcined, they are white as the purest lime. Whether concreted as pebbles, or crystallized as gems, they participate of the rich colours of all the earths in which they form. Equal parts of chalk-flint, of calcined bones, and of Cornish clay, constitute one of the best bodies of British porcelain. Primitive and alluvial sands, infinitely diffused on the whole earth, must have uniformly been concreted near the surface, the action of the atmosphere being highly solvent, would resist all larger concretions in that position. What a gracious design of Providence in favour of agriculture!

The various argilla, before supposed to be the sediments of primitive rocks, seem to occupy a greater variety of positions in the alluvial than in the primitive earth. The positions of their strata are much divided, lying between sands and gravel, on the one hand; and rocks and schistus, on the other. Hence also their great variety of colour, character, and loamy mixtures. The tides have so amply distributed them through all parts of the earth, that there is no deficiency, except on the summits of mountains, and in sandy places, which the united industry of ages is called to remove.

Clays, as rocks and minerals, are divided into species, families, and varieties. Native argil is a pure white; but it is a phenomenon to find either native earth or mineral in a pure state: the specimens vary much. The porcelain clays approach in colour to the grey, the yellow, and the white. The Cornish porcelain clay contains a small proportion less of silex and more of argil than the clay of Limoges; but this is remedied by adding more of flint and bone in the composition. Pipe-clay, is very adhesive to the tongue, and greatly increases its whiteness by burning. Our Hampshire fullers' earth, much enquired for in specimens by foreign chemists, is neither adhesive to the tongue, nor effervescent in acids. It has a resemblance in colour to some specimens of the Cornish clay, but contains a greater proportion of silica, and possesses in a high degree, the power of converting the oil in unfulled cloth into soap.

Ochres, and all argillaceous pigments, whatever be their tints, are classed among the families of clays. The Leskean system ascribes their colours wholly to iron. The colour of rudd, reddle, or red-chalk, proceeds from oxygenation, and the absence of acids; while the yellowish appearance of some clays, and the yellow of ochre, are tinted with the calces of iron highly oxygenated.—But the effect of other minerals must not be excluded from the theory of coloured earths.

On no subject, perhaps, is our knowledge more limited than on the cause of colour. Whether colours are inherent qualities of certain bodies, or whether they wholly proceed from various dispositions of the laminæ, are secrets of which science cannot speak with confidence. The crystals of iron and of pyrite-ores are white; yet when their oxides are decomposed, the sulphat or copperas is green. Copper also gives vitriols of various colours; and in general, if tin and antimony are excepted, the colours of precipitates vary, as we vary the precipitating agents.

This subject, being intimately connected with the latent colours of the earth, merits a consideration here. Brogniart, almost two centuries ago, wrote on enamel colours. Neri has since written on the stains of glass: Merret, and afterwards Kunchel, have added notes to the last work. The subject has been discussed in the ninth volume of *Les Annales de Chemie.* Our Encyclopedias are very deficient on this subject. Gold, with various proportions of silver, give both the rose colour and the purple in various shades; while pure silver gives the amber only. Reds are obtained from calcined copperas and vitriol, carefully washed from the acids. Yellow from four parts lead; two parts tin; and one part antimony. The purple blue, from Manganese, which is changed to a mulberry, by adding a sixth part of lead. The common blue of table ware is wholly from cobalt, purified as much as possible from bismuth and nickel; and the calx cassii, or high blue, lately discovered by the French, is one part gold, and five parts tin. The various greens are from copper; but the Chinese still surpass us in one of its shades: it is difficult to separate the copper wholly from iron, which injures the colour. The white is from arsenic, and the black from amber and cobalt. These are the primary enamel colours, of which the various shades are made by varying the portions, and by increasing the fluxes, which consist of borax, glass, and lead. By the essences of these minerals all the various gems of nature are tinted, and with beauties superior to art, because the colour maker cannot equal nature in the purity of his preparations: yet our landscape painters, on porcelain, have exhibited specimens, which will survive the canvass, and prove to future ages that the art has nearly approached perfection.

These hypotheses of colour may receive some farther illustration, though not a solution, from the prismatic colours of light; for each increase of radius in the prism presents a new colour to the eye. It is the same in the iris or rainbow. The seven primary colours lie from the earth in the following order; the violet, the indigo, the blue, the green, the yellow, the orange, the red: but when these rays are converged in a focus, they appear white or bright as the sun. If the bow be seen in the speculum of water, the colours appear inverted. If the shower fall through two clouds, the upper cloud reflects less distinctly than the water, a second bow, where the colours appear inverted likewise. This semblance of inversion arises solely from the position of the spectator. When the trees on the opposite side of a river appear inverted, on crossing the water, and stooping, they appear uninverted, and if I could raise the opposite side of the river to be almost perpendicular, both the trees and the bow would appear in a direct position. This simple exposition copied from nature herself, I am aware, is at dissonance with our opticians. They explain the phenomenon of the inversion of the colours in the second bow, by placing two sides of a triangle in the drops falling through the first bow, and three sides of a square in the drops falling through the upper bow. These squares, which have found their way into every plate of optics, I regard, speaking with deference, as conjectures which offer violence to the laws of refraction.

The primary colours are exhibited by polished mineral, almost as distinctly as by the prism, and by the reflection of water. At the Hayle copper-works, while a thick piece of red hot copper was under the hammers, I observed, that each knotty chip, cut off by a chisel, beautifully exhibited all the seven colours. It is the same with the scum of lead removed from the bright liquid metal: and also with a highly polished poker put into the fire till the end is red with heat. The ascension of the red heat disturbs the laminæ of the iron in various degrees, and exhibits in its progress all the seven primary colours. Consequently, we are still left in uncertainty, whether colour be an essential quality of bodies, or whether it wholly depend on the disposition of their laminæ.

Since the deluge of Noah, very important changes have been induced on the surface of the earth by the sea, and in the bosom of the earth by volcanoes, and earthquakes.

The sea, making an incessant war on the promontories, has deposed its washings in the calmer retreats and inlets of the tides, and sometimes changed the course of rivers, and often warped up bays and harbours in all parts of the earth. Canterbury, now twelve miles from the ocean, was once a sea-port, and its harbour opened with a double channel round the Isle of Thanet. The Rev. Mr. Ray reports, in his three discourses on the wisdom of God in the creation, that a ship's anchor was dug up at Westbere, three miles below the city, and another at Broom on the opposite side; and that the ancient anchorage, abounds with oyster-shell, and other marine fossils. At Reading, it is added by the same author, that a stratum of oysters extends over six acres of ground, and about fourteen feet below the surface. The like phenomena occur in Gloucestershire, and on the shores of the Rhine, and the Ohio, and it is believed, in the lower ground of most rivers. Herodotus reports, in his Calliope, that the Nile and the sea had warped Lower Egypt as much as eight or nine cubits; and since his travels in that country, the Lake Mereotis, then sixty leagues in circumference, is now scarcely twenty. The Dutch, almost in our own times, have gained a country by banking off the seas. In Cheshire also, indisputable marks appear of the retreat of the sea from its ancient bounds. As the abovenamed Joshua Hancock was digging Goodman Lunts' pit, in the valley below Talk-o'-th'-Hill, twenty feet below the surface he found under a quagmire, a six-inch stratum of mineral clay, almost impenetrable. After lading the puddle of the morass, and breaking this indurated stratum, he came to the dry dusty bottom of a river, bereft of its stream; and in the midst of the bed, was a row of hipping-stones, obviously worn by the feet of passengers! The depth of this forsaken river, is, as near as I could estimate, parallel with the present Meres of Cheshire.

With regard to inundations, which have very much increased the retreat of the sea, a very considerable one happened at an early period after the deluge, and which has almost escaped the notice of historians. According to Cedrenus, as quoted by Eusebius, it overflowed Thebes, the capital of Upper Egypt, and drowned Ogyges, the king, who had founded the city. The learned Varro places this inundation, as fifteen hundred years before the building of Rome. Pliny attributes its ravages to a comet, whose revolution was 565 years. In the time of Ogyges, says Augustine, in his city of God, there happened a flood, not general, like that of Noah; but greater than that in the time of Deucalion. In Helvicus's chronology, this inundation is placed as happening 531 years after the deluge of Noah; that of Deucalion is placed, by other chronologists, at a later period of 250 years, and in the year of the world 2437, according to Usher's chronology. These inundations being credited by so many early writers, induces me to think Mr. Bryant mistaken in referring them to the deluge of Noah.

The effects of inundations subsequent to the deluge, are very conspicuous, especially where elevated tides have sported on the lower grounds. On the levels of the Trent, parallel with the high-water mark, are thousands of oak trees, covered in a morass of blue clay, from four to seven feet deep, which the farmers dig up and rive for fencing, after the manner of park paling. Some of the trees lie at a greater depth, and others, which once lay on or near the surface have perished by the action of the air. The sap of the timber is decayed; and though the heart seems unimpaired, it decays also after being two years exposed to the air. The roots, however, sawn from the trunk, and placed edge-wise in a fence, will endure for twenty or thirty years.

Since examining those ancient remains of the vegetable kingdom, I have often reflected on the cause, and its operations, and have come to the following conclusions, which to me appear satisfactory. 1. That the inundation, which laid them prostrate, happened at the autumnal equinox, because of the multitude of hazle-nuts which are dug up in perfection of figure. 2. That it happened at an epoch sufficiently distant from the deluge of Noah, for the timber to attain the highest perfection, and while the arts were in a state of infancy; for in 1816, a war-canoe was dug up near the Witham, which runs from Lincoln towards the sea. 3. Though many of those oaks, lying in the deeper parts of the morass, seem to be a deposit of the waters; yet others less deep, and regularly disposed with their roots towards the west, and their branches towards the east, appear to have been blown down by an equinoctial hurricane, their roots being first loosened by the erosion of powerful tides. 4. That the morass, into which much of this timber was thrown, and the washings of morass and warp laid upon the other trees, have a very extraordinary property of preserving all kinds of vegetable and animal substances, without petrifying them, as is the case when they are laved among siliceous earths. This may be attributed to the purity of the clay, and the moisture of the incumbent stratum which excludes the air; to the tanning principle of the oak, which has tinted the clay to a dark or blackish blue; and to the iron, which so much abounds in heath-plants, that an equal portion of calcined lime and these plants will yield sulphat of iron. 5. Though, after a considerable residence near the above levels, I had no means of ascertaining the exact height of the waters during those inundations; yet I was fully satisfied, that an elevation of less than ten feet, above the usual high-water mark of equinoctial tides, was more than adequate to produce all the effects which have occurred there, and which natural history reports to have happened on the Rhine, the Oder, and in other parts of the earth. 6. In a word, the slow progress which the daily tides have made in warping up these levels, and all other retreats of the turbid waters, is to me a chronomecal and satisfactory proof of the truth of the Mosaic history; for as little is done in the thickness and enlargement of these horizontal strata, as could possibly be expected in the lapse of more than four thousand years.—On what ground then can a geologist embrace Count de Buffon's theory, that the earth has been formed by an eternal war of the ocean against the base of cliffs and promontories? Why are not all the mountains washed level with the plains, and the whole earth a dull and weary savannah of nearly equal level?

From the inundations of the sea, and the retreat of its waters, after warping up the lower grounds, I would endeavour to account for the strata of salt which extends for fourteen miles over the lower parts of Cheshire, and in some places at no great depth. The crystals are sometimes found adhering to small pieces of wood, which once unquestionably floated on the waves. At the mouth of every river, the daily conflicts between the tide and the stream naturally form a bar. And in places where the stream was weak, as in Cheshire, the obstructed waters would leave shallows, meres, or lakes, behind, on the irregular surface of the earth. These bars and banks would be overflowed by the equinoctial tides, whose waters, when evaporated to a certain degree, being greatly strengthened by the saline matter which would ascend from the lower strata of salt, which exist in that county, would form the strata successively, as now found.

A private letter from the Rev. Robert Carver, Methodist missionary at Ceylon, transcribed by permission, throws some light on this part of geology. At Hambantothe, opposite the Point de Galle, are flats, separated from the sea by a sand-bank, which contains a spring of fresh water. These flats, having no outlet into the sea, become inundated during the rainy season, with the rivulets from the neighbouring hills. The succeeding hot weather evaporates the lake, and a stratum of salt is left on the surface, in some seasons twelve, and in others fourteen inches thick. This phenomenon undoubtedly proceeds, not from the subterraneous access of the sea, but from the decomposition of the saline strata at some depth below the surface of the flats, which the rain-water will naturally do.

According to Mr. Blane, borax is deposited on the flats contiguous to a mineral lake of hot water in Thibet, almost in a similar manner. When the snow falls, they pump the waters of the lake on these barren flats, which are separated by an artificial bank from the lake; and when the snow melts, and the water evaporates, the borax appears on the ground, with the turbid deposit of the water encrusted on the upper surface. But the borax is only made on the same flat every third or fourth year.

At Cordona, near Montserrat, in Spain, is a homogeneal rock of salt, rising ninety toises above the ground, and a league in circumference. Its depth in the earth is not known. It is apparently without fissure, either horizontal or perpendicular; but, in some places, is slightly tinted with the oxide of iron, and with a light blue in others. It is thought to be a primitive formation of nature.

Brine-springs occur in a hundred places of Europe, and thin strata often above the level of the sea. But at Wielitska, in Poland, the huge mass lies about a hundred and eighty fathoms below the surface. It is worked in galleries extending a mile in breadth, and two in length. The town, excepting the church, is wholly below the ground, and the air admitted by ten pits. A copious river of fresh water runs at the bottom of the mine, and in a different direction to that of the brine, by which the people and the cattle are supplied. The huge mass of salt on the Carpathian mountains, seems likewise a primitive formation of nature, as the stratum is inclined.

The unquestionable occurrence of the inundation which overflowed Thebes and all Egypt, and of the later one which laid Thessaly, and other low places, under water, indicates a probability that the like catastrophes occurred before the deluge of Noah, and occasioned many formations of rocks and fossils, which geology cannot trace. At Scarborough, in Yorkshire, there is a stratum of heterogeneous granite, thickly crowded with eels. They are nearly all coiled, as is the spontaneous act of that fish in the time of danger; and the defect in the hollow of the head, demonstrates that they were once alive. A sudden irruption of the sea must have entombed them, with its eroted matter, at a stroke, leaving the mass to be farther stratified by succeeding tides, and crystallized by the ascension of subterraneous fluids.

Serpentine stones are found also in almost every country of the world; and stones which represent every species of the reptile brood. They occur in silica, granite, marbles, and in other calcareous rocks. Pliny mentions the *ophites candidus*, a species of fossil marble, worked into mortars and vases of ornament. Proof enough that all these marbles and rocks, containing the exuviæ of the vegetable and animal kingdom, have proceeded from the formations of water. The white marbles are accounted pure; the black receive their colour from iron; and all the countless variety in the marmorous classification, from the variation of mineral tints, which the acids have curdled, dappled, and sported, into every pleasing formation of latent nature.

The gypsums approach, in many of their properties, to the marbles, and are mostly formed in the horizontal strata laid on since the deluge. The crystallization is often effected in nodules of more than a hundred weight. The gypsum, in Cheshire, occupies a position a little above the salt, and has obviously been formed by the ascension of the gypseous fluid, to which the salt-rock below, no doubt, has materially contributed. Its crystals are often rhomboidal, and in some specimens they have a capillary, a striated, a fibrouse, or a downy and plumose appearance.

The changes induced on the earth by volcanoes, are placed in the Leskean classification, among the final considerations of geology. Where the latent heat causes the sulphuric and other acids to ascend through ferruginous strata, the heat continues to increase till checked by moisture, and the calybeate fountains issue forth in tepid temperatures equal to the augmentation of the warmth. But when the latent heat ascends in very high, peaky, conical, or full-breasted mountains, from whose steep declivities the rain so rapidly descends, as to leave the interior almost dry, it increases to combustion. The fires, being fed by air from a continuation of caverns, ascend the wide fissures towards the summits, and open craters, which ventilate the earth. And though the progress of these fires be slow through the constant opposition of water, and a scarcity of air; yet the bases of those mountains melt into lavas, which accumulate to prodigious masses, descend in caverns beyond the reach of thought, and often penetrate to a great extent under the seas.

Whenever any ramification of fire and lava, at the base of a volcanic mountain, has opened a communication with a lake, or new current of water, a conflict ensues proportioned to the strength of the combatants. The water is converted into vapour; its expansion causes the earth to tremble, the lava to boil, and the crater to utter many threats. But the lava giving way, prevents explosion. A black smoke, accompanied with flame, presently appears, and ignited stones are thrown out in every direction. These stones do not escape liquefaction for want of heat in the lava, but for want of time. Vesuvius ejected one in the irruption which happened in the year 1631, which fell on the Marquis of Lauro's house, at Nola, distant four French leagues, and burnt it. Stones, however, seldom fall at a greater distance from the crater than one or two leagues.

But where a ramification of a volcano has opened a wide communication with the sea, the conflicts and the consequences become much more tremendous. The pressure of the water is considerable, and to extinguish the fire requires time. Every puff of vapour, penetrating through the lava into a new vault, occasions roarings similar to the report of cannon of the largest calibre, as were heard in Mount Hecla, previous to the late irruption. On gaining possession of this new vault, it presses from the roof inconceivably upon the lava, forces it boiling to the vertex of the crater, or till it bursts its side towards the summit, and pours forth a most terrific and long-continued river of fire. The progress of the lava is rapid or slow, according to the ejective force, and to the declivities on which it flows. If the lava be highly calcareous, the flame has a whitish appearance; but if it abound with ferruginous and pyritous qualities, the flame is bluish. and discovers the mineral qualities of the lava. A scoriæ arises on the current, which darkens in colour, and encrusts as it cools, under which the lava long continues to flow.

Vesuvius, by a succession of irruptions of this nature, has embossed its peak, and stratified itself as a prodigious piece of artillery. Its base must be stratified deeper than its summit is high, because the lava in irruptions would press into all cavities, and cool again in the calmer periods of its history. Once it buried the city of Herculaneum, one hundred and twenty feet below the present surface, without allowing the unwary inhabitants time to escape.

Mount Etna, whose crater communicates, no doubt, with a ramification of the lava of Vesuvius, had, in 1669, the largest irruption ever recorded in Europe. The side of the mountain opened, and the lava issued forth, widening for the space of two miles, and about fifteen fathoms in depth. On reaching the sea, it drove back the waves with furious boiling, maintained itself to a considerable distance, and filled the air with impenetrable clouds of vapour.*

In the like conflicts of the elements, when the crater is inadequate to afford relief, or when there is in that place but a subterraneous communication with a distant crater, equally inadequate, explosion is the consequence, and destruction of the most tremendous nature. In this way, a mountain of the Andes exploded, and threw a detritus of eight inches deep on the surrounding country, sixty miles in length, and forty in breadth! This could be effectuated only by the sudden bursting of a lake of waters on an extended body of ignited lava, reposing in the cavity of the mountain. The like calamity has never happened to Chimboraso and to Cajamb, which have the rich valley of Quito in their bosom, their craters being adequately large.

Respecting the volcanic island of St. Michael, the most eastern, and largest of the Azores, we have, in the history of Captain R. A. published in London, 1813, gained many interesting particulars. In figure, it resembles a kidney, being forty miles in length, and about fourteen in breadth.

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* See Dr. Burnett's *Theory of the Earth.*

The peak appears at sea as an elevated cone, whose sides and base are equal. The vertex of the crater, at Porto Fermoza, is about half a mile in diameter. It sometimes sends puffs of vapour and smoke to the height of five thousand feet; and if a thick cloud happen to be passing in the night, on coming in contact with this effluvia, a beautiful zigzag lightning is the immediate consequence. Other small craters in the island are apparently branches of the great one.

About the year 1700, Pico de Fogo, or *Peak of fire*, having burnt its interior very thin, the sea burst in upon the crater, and occasioned a dreadful explosion, which destroyed three thousand people in Villa Franco. But the crater bursting seven feet under the low-water mark, and thereby becoming completely extinguished, and almost filled with lava and detached rocks, has formed a small harbour for shipping. The lava here, being mixed with iron, does not decompose, as elsewhere, to form one of the richest soils of nature: it continues to retain its barren and vitrous characters.

Pico de Fer, derives its name from the abundance of ferruginous ores contained in its bosom. The mine was worked at a remote period, till an explosion having entombed the miners, all future efforts became discouraged. The sides of the old mine, and of the caverns, are encrusted with nitric and sulphuric formations, which sometimes ignite and explode.

Both the lakes in this island, our well-informed traveller considers as extinguished volcanoes. And though he found lavas dispersed all over the island, he found rocks also regularly crystallized, and retaining all the characters of their primitive formation. The red river, issuing from Pico de Fer, proves also, that the strata of iron ores it contains, have not at all been disturbed, except where the volcanic fires have actually reached. In the adjacent island of St. Mary, he found a pottery, and strata of clays, without the least appearance of lava, What can the Christian geologist ask more? Here is a three-fold demonstration; a three-fold chronometer, in the rocks, the ores, and the clays, that this grand volcano in the midst of the western ocean, though constant in operation, has to the present day made comparatively but a small progress in converting its vicinity into lava. It is a three-fold chronometer, supported by every other volcano of the earth, which exhibits the like proofs. We have, in fact, the like three-fold chronometer not only in volcanoes; but in the slow march of sandy deserts; in the small increase of hills, formed by sands blown from the shores; and in the almost imperceptible retreats of the sea from the depoits of its estuaries. Nature herself every where seems to raise her voice to justify the scribe of nature.—Which then of the two is most credible, the prescribed chronology of Moses, or the chronology of his antagonists, which asserts the eternal war of the two elements, water and fire, and boasts of the immeasurable periods our continents have endured?

It ought here to be added, that explosions sometimes happen in the sea, and occasion a rising, or a sinking of the earth. Whenever the ramifications of a volcano, extending far under the sea, happens to be attacked by an irruption, the expanding vapour forces up the vaulted crust of the earth, and the distant lava rushing in to occupy the vacuity, sustains the elevation. Thus Santorini, and the two adjacent islands, at some unknown period, were elevated. Thus Isola Nova, a fourth contiguous island, made its appearance in the year 1707. The sea, for many leagues round, became coloured with sulphurous matter. Stones, lava, and mineral substances were forced up above the surface of the sea. A ridge was presently formed, reaching to the little island of Cameni; the several masses which appeared above the sea gradually rose higher, being united in their base, forming the new island, two leagues in circumference. The flames next became more conspicuous, and about sixty small craters were counted, vomiting smoke, flame, and ignited stones. The soundings before Villa Franco, in St. Michael's, once eighty fathoms, were raised by the beforenamed explosion, to be but four or five fathoms deep. Other islands, on the contrary, have sunk in the sea, as the Poco of the Molucca Islands, said to equal in height the Pike of Teneriff, which suddenly disappeared, and left no trace behind. The earthquake of Lisbon, which happened in 1755, and destroyed half the city, is fresh in the memory of aged men. The conflicts of nature continued for many hours. The pier-head of the city sunk a hundred fathoms below the Tagus, and about 60,000 persons were drowned or perished in the city. The shocks reached to Barbary, and the miners near Castleton, in Derbyshire, fled from their work, being alarmed, as they thought, with the report of cannon in distant parts of the mine. The principal crater, which occasioned this calamity, is thought to have opened westward in the sea. The catalogue of earthquakes is large, and crowded with very instructive examples.

Very considerable rivers and rivulets often run in the vicinity of volcanoes, and, in some instances, far exceed the boiling heat. The Furnas of Caldeira, in St. Michael's, are seven. The lava, at some remote period, having overflowed the spring-head, has been forced into these apertures, the largest of which is two feet in diameter. The water from each is ejected twelve feet high, and, in recoiling to the earth, discharges a cloud of vapour. The water is hereby much cooled; yet, when collected again, it will boil an egg in two minutes. The heat of the rivulet in Mount Hecla is apparently greater, as it boils a shoulder of mutton to rags in six minutes. These waters convey to us a standing proof, that the combustion of volcanoes is regular in its progress; and that their internal heat is greater than any pyrometer, which nature has hitherto afforded, can possibly ascertain. Providence has but to give a free access of air to those mountains, and they would burn tremendously, and deride the obstruction of water; for the sea itself abounds with calcareous and combustible matter. Most assuredly, there is no discovery of chemistry, all consummate as the science now is, which is repugnant to the uniform doctrine of the scriptures, that "the earth, and all the works therein, shall be burnt up."

But mere tremblings and concussions of the earth, are not now ascribed to volcanoes; they are thought to proceed from ignited gas. Our miners have been acquainted with the different gases from the earliest times; though the subject was utterly neglected by philosophy till within the last half century. When the cautious miner entered a shaft of bad air, in all cases, he made his candle the test of safety. On lowering it towards the ground in a thick heavy air, he found it ready to expire. This he called the *black* or *choak damp*, because on fainting in it, he presently expired. But on raising his candle toward the middle, it began to burn with a bright flame, arising from a mixture of oxygen: this he called the *white damp.* On continuing to raise it toward the roof of the mine, the flame lengthened to four or five inches, began to emit sparks, and assume a bluish appearance. And, it is dreadful to add, in a moment, the *fire damp*, as he called it, or carburretted hydrogen, exploded with an earthquake, disengaged rocks, laid prostrate the miner, and reduced the upper part of his body to ashes. Happy in cases where the lower airs could protect him, or where he could escape but half burnt. I once visited the overlooker of a mine, who had thus escaped. He had saved his sight by shutting his eyes, and a wet flannel shirt had saved his body; but his hair, his face, and hands, were dreadfully scorched.

Of the abundance of carburretted hydrogen contained in coal, and calcareous earths, we may form some idea from its long continued combustion in certain mines. Messrs. Aked and Mawson having, in 1809, opened a hurrying-road at the bottom of their pits in North Bierley, near Bradford, over a fissure sixty feet in length, and from one to four inches in width, the evolving gas became ignited, blazed to the height of three or four feet, and continued burning for three months. Having received this account personally from the former gentleman, and being attested by crouds of spectators, the statement is unquestionable. This gas has followed the stream of certain springs, and casually become ignited, by fetching the water on dark evenings with candle, or with old ropes which colliers burn as torches; and our fathers have venerated such fires with more than philosophic piety.

Consequently, whenever this gas becomes ignited in the deeper caverns; and providentially, it ever makes efforts to escape, a concussion must ensue, proportioned to the expansive force of the ignited air, and of the water it converts to vapour. But deep mines, much extended in gallies and shafts, happily tend to ventilate the earth, and diminish the excesses of latent heat.

Our protection and defence against all the irruptions of nature, and visitations of providence, lie with our Maker. The precaution of mortals, how far soever it may extend, is often unavailing. Our grand concern is regeneration, a good conscience, and a rectitude of temper, which delights to converse with moral truth. The studies of nature should all be directed to a more enlarged acquaintance with the God of nature; "For the invisible things of him are clearly seen, being understood by the things that are made, even his eternal power and Godhead." With these sentiments, the scripture characters have ever contemplated the glories of the heavens, and the beauties of the earth. To write books of science without piety, is to deviate totally from ancient example, and to sink below all heathen authors, who had the least claims to moral decency. Sentiments of faith and piety elevate science; they trace the relations of God to man; they inspire a confidence in all his perfections. He is a Father; he sees; he knows; he cannot err. Creatures admitted into his secrets, and intimately acquainted with his laws, cannot but be dear to him. These laws will keep us from sin; will endear the hopes of immortality; and closely unite us to him, whom it is our best wisdom, and first duty, ever to worship and adore.

FINIS.

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APPENDIX.

FOUR months ago, I published the preceding Theory of Geology, and now fall in with the wishes of my friends, who solicit farther illustrations of the subject. Though the arduous nature of my professional duties allows me but little time for geological studies, yet it has afforded me liberal opportunities of contemplating rocks and cliffs, mines and shores, where nature most unfolds her latent beauties, and displays her majestic characters. And though groaning under inadequacy to trace the history of her formations, and develope her laws, I nevertheless have acquired some originality of theory, and become instructed in the duty of candour, with regard to what I deem mistaken theories in others, from a consciousness of my own ignorance, and a frequent discovery of my errors.

Since Werner, of Freyberg (*page* 30) gave the public a classification of mineralogy, many scientific gentlemen have been roused to survey the ruder appearances and deep recesses of nature, and seem as though they would persevere, till the whole upper surface of the earth be investigated, and all her minerals classed consonant to the superior light of modern science. Their efforts are laudable; and, with the exception of errors, their writings merit the attention of the public. The most beautiful minerals of Europe, and of many more distant countries, may already be seen in private and public cabinets, where alone mineralogy can be studied with advantage.

At the same time, I beg leave to repeat here, that I feel myself, as do M. de Luc, and other Christian geologists, revolted at some parts of the Wernerian system; and particularly so, at the following phrases, transcribed from the writings of his disciples. " The birth of continents;—the old and new continents;—the immeasurable periods these continents have endured;—the junction of the primary and secondary strata of rocks;—the anterior and the posterior formations of nature ! ! !" Perhaps there is a sense in which some of these phrases may be harmonized with revelation; but the theories have an appearance of being intentionally hostile to the Bible; and being imposing with novelty of science, and beauties of language, there is some danger lest young readers should give up Moses for Werner, and ultimately have no basis, when the geology of the latter comes to be superseded by the fluctuation of theories.

But he who complains of error, becomes in some sort responsible to prescribe a remedy. This having been attempted in the preceding theory, it is here proposed to recapitulate its prominent characters, and add illustrations from the best writers.

1. That God created the chaos, *ουκ εξ οντων*, in a liquid state, having the essence of all things within itself.

2. That each mineral, whether of earth, of stone, of metal, or of combustible matter, has its peculiar and unalterable essence, which collected by affinities, curdled in the chaos, and produced its formations by crystallized concretions.

3. That expansion, being the inseparable result of crystallization, the mountains rose spontaneously, oblated the yet soft masses by pressure, and threw them into every possible position. Many rocks would hereby become so fractured, as to be traversed by wedge-shaped rocks of other genera, or such rocks might be formed between them.

4. Clays being the exuding sediment of these operations, would soften off all primitive rocks by gneiss, or by schistus, and being profusely deposited on the surface of the orb by the turbid waters, would leave the fine shapes of landscape in their retreat from the mountains. In professor Jameson's mineralogy of the Scottish islands, we have a well-executed plate of the vertical strata washed by the sea at Portsoy, in which the wide beds of schistus alternate in colour with the white marble on one side, and with the greenstone on the other.

5. That from the creation to the deluge, innumerable formations would take place, as well on the surface of the earth, as in its deep recesses, which are now utterly inscrutable to the most enlightened science.

6. That the whole earth was washed, much desolated, and, often, deeply stratified, by the long-continued flux and reflux of diluvian tides. Consequently, while the interior of mountains, which opposed a firm barrier to the deluge, remain primitive, their declivities, and calmer bosoms, are mostly alluvial.

7. That all minerals of the old world once concreted, would retain their primitive figure, and be laid on in beds of sand, gravel, and conglomerate rocks, except in cases where they have been decomposed, as in the chalk, &c. But that all strata of clays, being reinvigorated with strength from the sea, would almost instantly become exposed to a chemical conflict, be seized in the succession of strata by the different essences, and formed into beds of granite, gneiss, schistus, porphyry, marble, gypsum, sandstone, puddingstone, brecchia, limestone, and chalk, consonant to the laws of the essence by which they were seized.

8. That the different beds of argillaceous earths, not formed into the harder rocks, have nevertheless been seized by congenial fluids, and are become concreted into argillaceous, micaceous, aluminous, or porcelaneous schistus, leaving the weaker masses in beds of variegated, waved, and striated clay. The alluvial warp is therefore regarded as the matrix in which all those essences acted: consequently, all transition rocks are less hard than the primitive.

9. That as every chemical process of mixed substances instantly proceeds to action, whether of decomposition, or of organization, so in those huge masses of deposits from the tides, the formations would presently take effect, and must of necessity do so, giving hardness to the new-formed strata, as the waters exuded, and leaving the larger crystals at leisure to perfect their figures in the rocks. Hence the upper surface of all transition rocks must be covered with fragments and conglomerate masses of the nether strata, as investigation every where demonstrates to be the case; they

being all formed during the 270 days in which "the waters prevailed on the earth."

10. That as the rains of the deluge fell for forty days, and the waters increased in every tide for a hundred and fifty days; and as the decrease of the tides continued a hundred and twenty days, we may be assured, on the most probable principles, that those decreasing tides would make, in many places, tremendous attacks on the new-formed rocks, leave them craggy and bare, and hurl many of their blocks and masses from elevated summits. This obvious idea, which did not strike me before, relieves geology of many difficulties.

11. That all minerals, whether of the metallic or of the siliceous class, proceeding from their essential fluids, have, wherever they chose to concrete, seized the clays and fossils, and converted them into their own essence.

If any geologist, who may be biassed in favour of the Wernerian system, shall doubt of these illustrations of the Mosaic theory, and think them founded on error, I would solicit him to revise the difficulties of the system to which he is attached. If every stratum of earth, descending from the highest mountains towards the sea, be *younger* than the bed on which it rests, and if the number of those strata can scarcely be counted, what can this system be but Buffon's fond notion of the *eternal* war of the sea against the cliffs? But lest I should be accused of mis-statement, I will cite the words of a writer in the Annals of Philosophy for January, 1816, page 65. "The different beds of which Great Britain is composed, viewed on a great scale, dip to the east, or south east; so that by travelling west, we come always to *older and older formations*, till at last in Scilly Islands, Argyleshire, Inverness-shire, and Ross-shire, we come to the *oldest* rocks of all: those called primitive, and which contain no petrifactions."

Of course, I think the above passage exceptionable; that it is encumbered with difficulties which can never be removed; and that it should not have appeared without a comment.

NOTES AND ILLUSTRATIONS.

Page 10. *The schistus* [of the primitive earth] *invariably occupies a middle position between the rocks and the loamy earth.* Professor Thomson, who may be regarded as the most scientific man that has made a geological tour through Cornwall, coincides with this opinion. " Clay slate [the killas of the tinners] rests," he says, " upon the granite range. The primitive granite of Cornwall appears to constitute a tract of no great height or breadth, extending from Land's End to Dartmoor in Devon, a length of about 120 miles. About half way between Bodmin and Launceston, you cross another granite tract. It would seem that it branches off from the other granitic range nearly at right angles, or perhaps the range becomes wider at this place than usual. The *clay slate rests upon the granite range both on the north and the south side.* These observations, which I made in a variety of places, leave no doubt that this extensive bed of clay slate every where covers the granite, and is no where covered by it. It is likely that the granite rock extends very widely, and may even constitute the basis of the country; for the mines are all situated in the clay slate, frequently at no great distance from the granite." *Annals of Philos.* vol. ii. p. 348.

The learned Professor, at page 252 of the same volume, gives us a scientific description of St. Michael's Mount. " Its whole northern base consists of clay slate. On the south side, the granite continues down to the water's edge, and it continues to constitute the whole of the hill both on the east and the west side for three-fourths of the whole extent. Then we come to the clay slate. On the east side, where the granite terminates, numerous veins of it run into the clay slate in different directions." In a word, as the beds of granite are mixed with the beds of clay slate, the Professor considers it " beyond dispute that the granite of St. Michael's Mount is not *primitive* but transition granite. This is the conclusion that Mr. Allen ought to have drawn, and the conclusion he would have drawn, had he given his reasoning power fair play."

Professsor Jameson, (vol. ii. p. 271.) gives us a plate of the beautiful vertical strata at Portsoy. The stratum of micaceous schistus lying between the white marble, and the greenstone strata alternate in colour, being blackish contiguous to the marble, and greenish towards the greenstone rock.—Schistus, no doubt, occurs between the masses of primitive, as well as of transition rocks.

Page 16. *The mountains began to rise on the third day.*—Professor Cuvier, of Paris, has published a theory of the earth, which bears strong characters of genius and experience. He regards " the rocks which constitute the highest and most extensive chains of mountains upon the earth's surface, as containing no animal remains. Hence, he justly infers, that they must have been formed before our planet was covered with vegetation, and inhabited by animals. But as these rocks are composed of beds placed in the most various and dislocated state with respect to each other, he considers it as evident that their position has been altered since their original formation, and that they have been elevated by some unknown agent to their present lofty position."—*Prof. Thomson's Annals of Philos.* vol. iii. p. 143.

What can this " unknown agent" be, but the expansion inseparably connected with crystallization, as is stated in the 9th and 10th page of the preceding theory, which would oblate the curdled masses, and by continued pressure would break the strata, and give various proportions of dip to primitive rocks, throwing some into a vertical, and others into a topsy turvy position?

Page 18. The former are denominated *alluvial*, and the latter *primitive*. Werner has divided rocks into *primitive*, *transition*, and *stratified*. This theory of lithology is now generally followed by geologists. The primitive are destitute of all organic remains of the animal and vegetable kingdom. They comprise granite in a greater proportion than all others put together, which lies in strata, divided by fissures into huge quadrangular blocks and masses. Every other species and variety of rocks are comprised in the primitive, but without alluvial erosions, as limestone, gneiss, quartz, greenstone, pitchstone, mica, sienite, porphyry, and all the variety of schistus.

2. The transition rocks, he distinguishes, as do others of his disciples, from the stratified, by laboured efforts. They are said to comprise sandstone, grey wacke, limestone, greenstone, sometimes porphyry, and all the varieties of schistus; and to contain but *a small proportion* of shell and vegetable fossils.

3. The stratified, or floetz rocks, are defined as containing all other kinds of rocks, and as abounding in marine and vegetable remains; and as containing coal of every family and species, and basalts, which, both in the Giant's Causeway in Ireland, and in the Scottish Islands, are formed near the surface. The basalt quarry also, at Rowley, eight miles west of Birmingham, is close to the surface, and rises in a succession of columnaral ranges.

The theory of Werner is farther illustrated in an extract from "*Mineralogical Observations by Robert Jameson, Esq. F. R. S. E. Regius Professor of Natural History in the University of Edinburgh.*"

"The Mineralogical investigations I have been engaged in for some years past have enabled me to make several interesting observations. The following short enumeration contains a few of the most important of these.

1. That primitive rocks contain no mechanical deposits, the conglomerated rocks in gneiss and porphyry being entirely of a chemical nature.

2. That greywacke is always a pure chemical deposit, and contains no mechanical intermixture.

3. That feltspar occurs more abundantly in nature than is generally supposed, this mineral being one of the constituent parts of granite, gneiss, clay slate, porphyry, sienite, serpentine, flinty slate, hornstone, greywacke, transition slate, striped jasper, oldest conglomerates, besides forming, in some degree, the basis of most of the primitive, transition, and floetz trap rocks.

4. That the vast beds of conglomerates which rest upon, and, sometimes, probably alternate with transition rocks, are also chemical deposits.

5. That sandstone, in many instances, appears to be a chemical deposit.

6. That many of the fragments and fragmented appearances which occur in porphyry, limestone, and trap rocks, are of a chemical nature, and of cotemporaneous formation with the rocks in which they are contained.

7. That true primitive veins, those confined to primitive rocks, whatever may be their nature and magnitude, are often cotemporaneous formations with the rocks they traverse.

8. That many veins in transition and floetz countries, even those extending

for many hundreds of yards, and of great width, are of cotemporaneous formation with the rocks in which they are contained.

9. That strata of crystallized rocks may appear to run beneath the older rock when they really rest upon it, and have been formed after it.

10. That the various wavings in strata of gneiss, mica slate, clay slate, greywacke, transition slate, and sandstone, are the effects of crystallization.

11. That the general, physical, and geographical distribution of petrifactions in the crust of the earth, does not correspond with the existing races of animals and plants."

To most of these observations, I fully accede. They are the result of much study and accurate observation. Yet I doubt whether some geologists properly understand one another concerning *chemical deposits.* Count de Saussure is fond of the term; and M. de la Metherie, editor of *Annales de Chemie*, ably combats him in that work on the impossibility of granite, &c. proceeding from deposits, because of the crystillization, and because of the varieties of structure in those rocks. It strikes me the more, that the Mosaic theory of stratifying the earth by the long-continued action of tremendous tides, is the only one which can correct the contradictory theories of geologists, and illustrate the phenomena of the stratified earth.

As to petrifactions not agreeing with the existing races of animals and plants, our Professor must be aware, that many naturalists have in their cabinets, a vast variety both of animals and plants in which the exactest resemblance can be traced. The human skeleton in the British Museum has an undoubted correspondence to the present structure of the human body. M. Cuvier, of Paris, has taken up this subject in so able a manner, as to convince any one, I should think, who might have entertained doubts. He has carefully distinguished the fossils of very many plants and animals which appear to be extinct, from those which now exist.

Professor Blumenbach, of Gottingen, says, in a letter to Von Moll, "That though he had hitherto disbelieved the occurrence of vegetable bodies in the dendric variety of chalcedony named *mocha stone*, he must now admit that it does sometimes contain true vegetables, apparently of the nature of *conferva*." —*Annals of Phil.* vol. i. p. 217. [*See the next note, and page* 13, *on the formation of dendrites.*]

Page 18. "*The alluvial* [strata] *contain petrifactions of all animated nature, and remains of vegetables and animals now extinct.*"—It is not many naturalists who object to this theory; yet it has been said, that these fossils are a *lusus naturæ*, or the mere sportings of subterraneous nature. This induced Dr. Woodward [*Nat. Hist.* p. 23.] to investigate the subject with the greatest care. "The fossils," he says, "being precisely of the same size and shape with others, of the same substance and texture, and constituted and disposed in the same manner, as their respective fellow-kinds at sea; the tendency of the fibres and *striæ* the same; the composition of the lamellæ, constituted by these fibres, alike in both; the same *vestigia* of the tendons by which they are fastened to the shell in each; the same papillæ; the same *sutures*, and every thing else whether within or without the shell, whether in its cavity or convexity; answering all the chemical tests as sea-shells do; having the same effects, administered in medicine; their parts when dissolved have the same appearance, the same smell and taste; aqua fortis, oil of vitriol, &c. have the very same effects on both".—Hence the Doctor afterwards concludes that, these fossils are what they appear to be, the remains of destroyed animals and perished vegetables.

In Professor Jameson's Minerology of the Scottish Isles, we have an account of the position of bivalves in a strata which he examined. "In Arran, about a mile from Cory, and nearly a hundred feet above the level of the sea, there is a stratum of limestone, about 12 feet thick,—and below, interposed between the limestone and the sandstone, there is a layer of red schistose clay. In this clay I observed a regular series of shells deposited in layers, all appearing of the same species, *with their convex sides downwards.*" vol. i. p. 68.

This is proof sufficient that these shells are the deposit of deluge; as all bivalves adhere to rocks in families, and never lie on their sides. There is another fact, which utterly overthrows the opinion of geologists of the unbelieving schools, concerning the formation of primitive, of middle-aged, and juvenile continents; it is, that these shells occur in clays, in chalk, in limestones, in sandstones, in marbles of every family and species: but shell-fish, when alive, always adhere to rocks. These shells also occur in basaltic veins which traverse other rocks; and consequently of posterior formation.—*Kirwan's Geological Essays*, page 252.

Shells occur in the Alps, according to Saussure, 2800 feet above the level of the sea. Von Buch found them at various elevations above the level of the sea from 20 to 500 feet. [*Travels in Norway.*] Dr. John Fleming, on examining the bed westward of the town of Borrowstounness, on the Clyde, says, "The shells in this bed are of a very large size, and must have belonged to aged individuals. But in general the valves are detached, and the shells broken into moderately sized fragments; so that the bed [a stratum much mixed with sand, as he afterwards adds] presents an appearance of confusion." *Annals of Philos.* Aug. 1814. Here is farther proof that these shells were laid on by deluge, for they once adhered to rocks, bowlders, &c. and not to sand.

Page 21. *The same aluminous warp* [meaning the deposit of impetuous tides] *would form marble* or porphyry, *or gypsum, or alum.* The Hessian marble, abounding with impressions of the broad-leaved willow, has every appearance of an alluvial formation. The gypsum of Cheshire, as well as the nodules of alum in the north of England, is unquestionably formed in strata of clay. A notice to the same effect occurs in Professor Jameson's Minerology of the Scottish Islands. Between "the farm Drumoodon and Tory-Lin in Arran, the whole shore appears to be composed of *clay-porphyry.*" vol. i. p. 109. A little farther he remarks, "that the porphyry is traversed by basaltic veins; and in some places from one to ten feet thick."

Our scientific traveller more than once remarks, that traverse veins occur in the form of a wedge. I can see no way of accounting for veins of basalt, of sandstone, of porphyry, &c. traversing granite and other rocks, but on the theory of copious deposits by impetuous tides. Suppose, for instance, that one tide should lay twenty or thirty feet of warp on a declivity, which has a considerable dip; the weight of this soft mass, during the absence of the tide, would open a hiatus in the form of a wedge; and the next tide, filling it up with warp of other qualities, would, on the whole becoming transition rocks, give all those various appearances which now embarrass the lithologist.—The like phenomenon might occur to the curdled masses in the creation, and be extended to much greater lengths of traversing veins than in alluvial rocks. Of this I feel satisfied, that the veins of clay in many of the chalk rocks could proceed from no other cause than a hiatus.

Rohault coincides with my theory that transition marbles were formed in clay. "La production du marbre ne differe pas de celle des pierres les plus communes, si ce n'est que l'argile dont il est fait a ses parties beaucoup plus petites, et ses pores beaucoup plus serrez, lesquels par ousequent peuvent etre plus facilement remplis par les exhalaisons qui s'y arretent."

Page 26. *The deeper strata of the earth would be laid on while the waters were rising.* This idea relieves geology, while the Wernerian system seems thrown into complete confusion by the occurrence of floetz rocks and sands, and coal under rock, which it has laid down as primitive. Professor Jameson, speaking of formations, gives Von Buch's account of "small hills in the valley of Locle in Jura, from 200 to 300 feet high. The lowest stratum of these hills rests on coarse conglomerated masses of limestone, on which rests a pretty thick bed of marly limestone, which has a white colour, is fine, earthy, and almost friable. Throughout its whole extent it is intermixed with small *river-shells,* which still retain their natural shell. Small reeds also occur every where in this bed. In the middle of it we meet with beds of smokey-grey hornstone, which has a fine splintery, or imperfect conchoidal fracture.—Below the hornstone lies a bed of *opal,* of a brownish colour, glistening lustre, and perfect conchoidal fracture, coloured with the coaly matter of decayed vegetable. To this succeeds a bed of *bituminous shale,* which contains many impressions of reeds; and next, a bed of *coal,* including many bivalved shells. This coal burns badly; yet it is used by blacksmiths when a strong fire is required. These beds are but a few inches thick, but alternate two or three times as we descend; and it is said, they sometimes attain the thickness of two feet—We thus see what lakes have produced: hills of 300 feet in height, and compact siliceous beds which are almost crystallized."

That Von Buch saw what he here describes, there cannot be the smallest doubt; fresh water-shells, with canes and reeds, the produce of marshy grounds, abound in the Yorkshire iron mines; and yet these mines were unquestionably laid on, and stratified by the sea. I am of opinion that he examined those hills in haste; and had he taken more time, and been provided with means, he would have found them to abound also with marine fossils. His supposition that fresh-water lakes have produced stratified hills of coal, limestone, and many other minerals, is one of the most extraordinary that geology has any where advanced. That all these hills were laid on, and stratified by the earlier tides of deluge, and worn away to their present shapes by the later tides, not the smallest doubt remains with me. The like appearances of nature occur in a thousand other places.

The interesting hill of Taberg, ten miles S. S. E. of Jonköpping, in Sweden, has been described by many geologists. The following abridgment of Professor Thomson's description is the substance of what has been written. "It rises 420 feet above the surrounding country, and about 920 above the sea. Its base consists of thirty feet of loose sand; which, according to Ascanius, a Danish philosopher, contains bones of the stag and of other animals. The uppermost bed is about 370 feet thick, and has the appearance of greenstone, divided into blocks of quadrangular form. On taking up fragments, you are struck with the weight; and find that the greater part consists of magnetic ironstone. At the same time crystals, both of felspar and hornblende are to be seen very distinctly in it. The greenstone seems to have communicated the form and aspect of the rock; but the ironstone constitutes by far the greatest part of the mass; and contains from 20 to 32½ per cent. of iron. Between the rifts, in many places, I observed thin veins of calcareous spar. On the south-edge of the hill, there is a pretty wide vein of claystone. Its width, at the bottom of the hill, is about six feet, but it becomes narrower as we ascend. The dip of the hill is from seventy to eighty degrees. On the summit, I observed several loose blocks of greenstone."—*Travels in Sweden*, p. 288.

At the 376th page, our learned traveller adds, "The hill Taberg, it would appear, consists of mica slate; and the mine, I am informed, constitutes a vein. The vein-stones are mica, limestone, and asbestus."

I am glad of this last adjection, that the iron in the mine constitutes a vein; and think no one need to hesitate in pronouncing this whole rock to be of the transition class. The sand, being concreted prior to the deluge, and having no adequate base, remains with the almost mere resemblance of a sandstone. This huge mass of greenstone, a rock, which according to Mr. Emanuel Mendesda Costa, has an appearance of having been artificially laid on the sand, may be regarded, as proceeding from deposits of the earlier tides of the deluge, and consequently exhibiting veinstones as above. The vein of iron, though much dispersed in the rock, was a subsequent formation by the concentration of the ferruginous fluid; for many demonstrations have occurred to me in the study of iron-ores, that the fluid has a power of converting, not only clay, but all fossils, whether of animals or vegetables, into its own essence. The loose rocks on the summit of the hill, as well as its precipice towards the east, I regard as the ravages of the later diluvial tides.

Page 26. *Coal—once floated on the sea*;—and was laid on by a succession of the retiring tides. Mr. Keir, manager of a colliery near Birmingham, drew up an exact account of the situation of the coal, which was published in Shaw's History of Staffordshire; and has been transcribed by Professor Thomson. "Many *faults* occur in Coal-field. They are rents in the beds, which are usually filled up with clay.—By a great fault which occurs near Bilston, the dip of the coal is reversed; that is to say, the coal beds on the south side of the fault dip south, and those on the north side dip north."—This is the case, I believe, uniformly with the faults, called gauls in the Pottery collieries. What clearer proof can we ask of the coal being laid on?

In the Mull, a Scottish island, is a stratum of basaltic rock, which at Artown, "juts out into a promontory, and which presents beautiful ranges of basaltic columns. Upon the north east side, we observed a stratum of coal, which has for its roof a mass of imperfectly shaped basaltic pillars. It is about twelve inches thick. It is imagined that basaltic rocks are very unfavourable to coal."—*Prof. Jameson's Tour*, vol. i. 214. "The proprietors do not work this bed from an illusive notion that basalt is unfavourable to coal!" The same geologist farther observes, that "although *coal has never been observed alternating with primary strata*, yet it has sometimes been found in their immediate vicinity; and coal has never been found lying on granite."—Vol i. p. 238. The notion of granite being unfavourable to coal, is quite unsupported. The late Mr. Catcott is of opinion, that the granite actually lies not far below the Bristol coal. But as the tides laid on sands, which became sandstone, and clays, which became, in many instances, rocks of other denominations, it is almost impossible for the deposits of timber, afterwards changed to coal, to be found on primitive rocks.

Against the theory, that coal is a flotilla of timber and vegetable laid on by the deluge, it will be objected, that timber is often found with its colour and figure but little changed. Pieces of oak are found in that state in the Yorkshire iron-mines at a small distance from the veins; but mostly petrified. Carbonated wood often occurs in limestone but slightly changed. A chesnut tree was discovered at Rennes, with the sap converted into jet, and the heart carbonated. But though timber be sometimes found not much changed among rocks, it cannot at all affect the question of vast flotillas left on sands and clays by the tides of the deluge. For instance, the brow of Shooter's hill, eight miles from London, was cut, in 1817, to level the descent. On approaching, I thought I perceived a stratum of coal three feet from the surface; but found the change of colour had proceeded from faggots of oak, which had been laid in the ruts to support the wheels of carriages. This trivial occurrence, every where common, I deemed a demonstration that the colour and body of coal have proceeded from flotillas of vegetables. But what has most deceived geologists is, when a vegetable deposit occurs among rocks, proceeding chiefly from weeds and grass, with here and there a tree in the midst of it, petrified indeed, but not altered into coal, as it would have been had it fallen among the usual beds of coal. Nature, in such situations, being disposed to form rocks, has partially counteracted the spontaneous transition of such timber into coal.

Page 28. *Bovey coal*, so called from Bovey Tracy, in Devonshire, (the Brown coal of Scotland,) is described by Mr. Arthur Aikin, as having a "structure of wood, or of other vegetables."—*Manual of Mineralogy.* Its strata, no doubt, are coeval with other families of coal.

Foreigners have crowded their geological books with erroneous opinions concerning coal, for want, perhaps, of adequate magazines to study it. England is almost the only coal country of Europe. The beds abroad are so thin, as scarcely to pay for working. While around Birmingham, the main coal is thirty feet thick; at Middleton, near Leeds, about eighteen feet; and in Wales, very considerable: in Staffordshire, the beds often reach ten or eleven feet, while in the north of England they seldom exceed seven.

Page 36. *Two hundred fathoms.* Dolcoath mine is oblique in some places, and that is the depth which the miners gave me by estimate.—William Philips, Esquire, in an extended paper which he forwarded to the Geological Society, states the above mine to be 228 fathoms deep. He writes as a man of science, favoured with all the advantages of experience and local knowledge; and his paper is the most luminous and accurate of any that has been laid before the public. But when he mentions instances in which the lodes widen to 24 or to 30 feet, it must be understood that rocks of sparry quartz, &c. intervene, and break the vein. These lodes, he adds, are distinguished by names according to the nature of the veinstone. The following are the principal:—1. *Gossany*, when the veinstone is clay, mixed with silica, and oxide of iron. Its colour varies from a light yellow to a deep brown. This is the most common vein, and is considered as promising both for copper and tin. 2. *Sparry*, when quartz predominates. It is considered as rather promising. 3. *Mundicky*, when iron pyrites abounds. 4. *Peachy*, when the veinstone is chlorite. It is more promising for tin than for copper. 5. *Flookany*, when one or both of its sides is lined with bluish white clay. 6. *Caply*, when the veinstone is a hard substance of a greenish or brownish colour, chiefly a mixture of chlorite and quartz. Tin is found in it, but seldom copper. 7. *Pryany*, when ore is found in detached lumps. 8. When a vein abounds in blend, it is called a *black jack lode;* when it contains granite, it is called a *growan lode.*"—*Professor Thomson's Annals*, vol. ii. p. 67..

Page 38. *Portland stone in colour is whitish, obviously from its vicinity to the chalk.* This is apparent from the fragments, as well as from the colour. In the rampart-walls of Portsmouth, where this stone is kept soft by the earth behind, the fragments which fall by the action of the atmosphere, exactly resemble those of chalk. In the western quarries, a very beautiful ochre-coloured freestone occurs, less hard indeed than the blue, but equally hard as the white. These, as all other rocks, when first quarried, are soft and yield to the tool; but always harden by exposure to the air, except a superabundance of clay enter into their composition. So M. de Saussure justly remarks. " C'est un fait connu de tous les mineralogistes, que la plupart des pierres sont plus tendres dans le sein des montagnes qu'à leur exterieur, et qu'elles acquierent à l'air un degré de dureté sensible."—*Voyages dans les Alpes*, tome vi. p. 318.

Page 39. *Granite rocks—of Scilly.* It is now thirty years since I spent three months in the Scilly Islands. I was then but beginning my geological notices, and unacquainted with most of the terms now in use: but having read Ray and Derham, a delight in natural theology excited me to examine the rocks with care. The granite, on the south of St. Mary's, near the church, is of the same family with that of Land's End. The blocks are mostly quadrangular, and often cubic. Towards the summit, in some places, they alternate to a rough kind of gneiss. The dip, if any, is so slight, that I did not notice it. On the north of Tresco, and St. Martin's Islands, the granite presents a bold and ragged precipice to the breakers. But Samson's Island exhibits the grandest scene of desolated nature. The granite rocks are columnar; and rise about 120 feet above the low-water mark. I stood on the adjoining island during a strong gale to observe the sport of the waves. The great swells came every minute: the sea between them was perfectly calm. They broke over the columns, and almost twice their height in foam and spry. On the north of St. Mary's, when the tide was out, I perceived shelving rocks; whether of grey wacke, or of trap, approaching the greenstone, I am not certain; but from their dip in several places, I was satisfied that they were the base of strata which once projected over all the islands. And, consequently, the depth of the water being about forty fathoms near some of the rocks, these islands are the small remains of land which once extended far into all the surrounding sea. Having never noticed any organic remains in these rocks, I have always considered them as primitive formations.

Page 40. *The chalk rocks.*—Since writing the above, I have visited the Hampshire cliffs, the grandest magazine of Europe, where the chalk is seen *in situ* to advantage. In the Portsdown cliff, on the London road, five miles from Portsmouth, the chalk frequently abounds with tuberose balls of pyrites; I procured one which in figure resembled an artichoke, full of crystals with triangular faces. In this cliff, the skeletons of sixteen men have been dug up, interred in the chalk, about eighteen inches deep, and with their feet towards the east. Their bones are in a high state of preservation, and the lowest of them in stature appeared to be about five feet ten inches. One of them had a piece of iron forced through the cranium. It is supposed that about twenty more lie in the same direction where these were dug: but no historian has recorded the affair in which they fell. The virtue of the chalk must be great in preservation of bodies so thinly covered with soil. Now and then a belemite occurs; and echini *(sea hedge-hogs)* frequently. The echini in the chalk, are converted into chalk; and those in the strata of flint, are converted into flint: the shell, with its double rows of pricks in both instances, exhibiting a sparry appearance.

The chalk cliff at Fareham has nodules which weigh from 100 to 150 pounds. It is covered, on the side next the town, with beach-worn pebbles of very many kinds. While the chalk in this part was laid on by tides, and soft, it broke here and there into a hiatus, which is now filled up by clay and rubble, exhibiting the figure of a wedge.

At the Paul's Grove Cliff, situate at the head of Portsmouth harbour, I saw, for the first time, quadrangular blocks of chalk four feet thick, and about twenty in length: but these break into fragments by the action of the atmosphere. The nodules of flint are small and few; but in the horizontal strata, the flint is oblate. The rock is also traversed by oblate veins. A shell is now and then perceived in the chalk; but I could not procure any.

The dip is about seven degrees toward the north; and the depth of the cliff, I estimated at 430 feet. At low water, the termination of the bed can be seen sixteen feet under water half a mile south of Porchester castle. The draw-well at Portsdown, is 375 feet deep; and penetrates through the chalk. The well in the King's yard, two miles south of the place where the chalk is seen under water, is 200 feet deep; and a well in Portsmouth is 260 deep, and no chalk appears: but a thin stratum of weak iron ore occurs in the clay. The spring is in a stratum of sand.

Page 40. *Sands—concreted near the surface* of the earth, to form loamy soil for agriculture. Rohault, speaking of grains of sand, says, " Les partes qui

approchent le plus près de sa [la terre] surface les font si peu, qu'elles se trouvent separées les unes des autres par une infinité des fentes qui sont entr'ouvertes en tout sens, par ou elles donnent un libre passage aux vapeurs et aux exhalaisons."—*Traité de Physique.*

On recurring, at the close of these notes, to the first principles of this theory, it strikes me, that if God created the earth in a liquid state; if the essences of all things curdle, changed and formed by affinities; if primitive rocks proceed from crystallized masses, and if transition rocks and marls proceed from tides, all attempts of geologists to lay down a general theory of the earth's strata, must be unavailing. Mr. Catcott, in 1768, gave us a theory as applicable to some of the collieries around Bristol, where he resided.

" 1. Under the vegetable, whitish sandstone three feet thick.

2. A red marl six feet thick.

3. A blue limestone, containing shells and bones, about three feet thick.

4. A blue clay, containing selenites and pyritous formations, nine feet thick.

5. A grey flag-stone, twenty-four feet.

6. A stratum of coal, on which lies a blackish schist, abounding very often in vegetable fossils, six feet thick.

7. A rag-stone, thirty feet thick.

8. A free-stone, containing shells, thirty-six feet.

9. A grey limestone, containing corals, shells, &c. reaching to the primitive rocks."

Werner places chalk in the fifth strata: Brogniart and Cuvier, in their geological survey of ten miles round Paris, place it in the eleventh strata. Professor Thomson places chalk the fourth, viz. " Sand, clay, gravel, chalk." —*Annals of Philos.* 1816, p. 66. In Hampshire, the chalk, for a vast extent, is not covered with more than six inches of earth, composed of vegetable decomposition.

ERRATA.

Page 8, line 2, for chrystals, read crystals; and several succeeding pages.—P. 9, l. 29, read tetrahedron; l. 32, read isosceles—P. 12, l. 6, read collieries.—P. 19, l. 12, read roulés.—P. 33, l. 18, 19, transpose, eight and eighty.—P. 37, l. 37, for minerals, read metallic ores; and in several other places.

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APPENDIX.

No. 2.

A REFUTATION OF PROMINENT ERRORS IN THE WERNERIAN SYSTEM OF GEOLOGY,

AND OTHER THEORIES.

IN A LETTER TO JAMES HAY, ESQ. F.L.S.

Sir,

Impressed with grateful recollections for a sight of your cabinet, and for the instructions you gave me in Mineralogy, I have felt the more solicitous, to make an appeal to your judgment, improved by long experience, as to the propriety of the following strictures on the modern theories of Geology.—Though I have often strayed in the scenery of hills, and on cliffs and shores, where the formations of nature are seen to advantage; and though long acquainted with favourite authors of the elder school, whom I still esteem; yet of Geology I should never have written, had it not been for certain tacit or open disavowals of the creation of the world, and an unconcealed contempt of the doctrines of Revelation and Religion, obtruded as the basis of several modern theories. A perusal of those writings has therefore been thought a duty for the defence of natural Theology,; it being desirable that the Christian should read his Bible, and study Nature with equal delight.

The late Dr. James Hutton, a Scottish physician, has given us two editions of his Theory of the Earth. It comprises Buffon's notion of the eternal war of the ocean against cliffs and promontories, and the consequent formation of new continents by those erosions; a notion ably refuted by Von Charpentier, and others. It comprises also the notion of several French and German writers, that our present continents have been raised from the bottom of the sea by latent fires, and the consequent sinking of the older continents into the bottom of the sea again. Humboldt seems to have been reclaimed from those notions by a survey of primitive nature in the Isle of Teneriffe. "Nothing," says he, "is more interesting to the Geologist, than to observe the relations on the same point of the globe, between volcanic countries, and those which are primitive and secondary. When the Canary Islands shall have been some day examined, in all the parts which compose the system of those mountains, we shall find, that we have been too precipitate in considering the whole group as raised by the action of submarine fires."—*Miss Williams's Trans.* vol. I. p. 100.

The Doctor, however, was so assured of his theory, and so far confident of having gained his reader, notwithstanding the strictures of Kirwan, as to close his work with an avowal of his sentiments. His words are, "Having thus seen the natural history of the earth; seen the succession of worlds, we may from this conclude, that there is a system in nature, in like manner as, from seeing the revolution of the planets, it is concluded, that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in nature, it is in vain to look for any thing higher in the origin of the earth. The result, therefore, of our present enquiry is, that we find no vestige of a beginning; no prospect of an end."

It is not questioned but the Doctor's mother gave him suck; but it may be of moment to repeat a few enquiries once made in the schools. 1. Who nursed the first infant, and the first young of beasts and birds? because if they suddenly grew up to maturity of stature, and needed no nursing, then "we do find a vestige of a beginning." 2. How are we to prove that the number of generations, or succession of mother and child, is infinite? 3. In the revolution of the Doctor's planets, whose days must be of various lengths, and in the succession of worlds, which he says *we have seen*, how do his friends prove that the sun has really shone as long on one hemisphere of each orb as on the other? because the deficiency of one day mars all the daring scheme of the eternal duration of matter. 4. How do they explain the difficulty of an uncaused cause of so many geological effects. 5. If the Doctor's two last inferences be really correct, whether we may not superadd a third; if there be no beginning, no creation, if all formations are the eternal sport of atoms, it is to ask in a moral view, whether there be any more harm in the millions of animal formations recently cut down during the French war, than in the millions of vegetable formations which daily fall after the mower's scythe? An honest man will ever speak and act according to his creed. Nevertheless, if that honest man should happen to knock at my door, I should for a hundred reasons deem it safest to give him his answer at the door. To admit him as a friend, would be at the peril of all my future peace.—6. And as to the notion of "no end," if there be a God; a God who must possess moral perfections; a God who prompts a father to make his children and domestics responsible; Is it not most likely, that he will call his rational creatures to a final scrutiny?

In Professor Cuvier's Essay, mentioned page 63 and 70, several assertions occur which have a strong leaning towards the eternity of the world. This author has become known to the Public by a work on Comparative Anatomy; a work founded on facts; while his Essay has many conjectures of a very doubtful nature. He says, "There have not always been living creatures on the earth." He admits, though in the sense of Professor Werner, rather than of Moses, that "it is impossible to deny the waters of the sea have formerly, and for a long time covered those masses of matter which now constitute our mountains; and further, that these waters did not support any living creatures." Kerr's Transla. p. 17, 21. But he adds, at the close of his Essay, like the above author, "And man, to whom only a short space is allotted on earth, would have the glory of restoring the history of *thousands of ages* which preceded the history of his race, and thousands of animals that never were cotemporaneous with his species." When we have a high opinion of a medicine, we sometimes swallow the dregs with less difficulty. Hence the author reserved this word of grace to the 30th section. It is proper however to remark,

1. That the idea of an earth, a sea, and consequently an atmosphere, existing for a series of ages without supporting any living creatures, seems as absurd as the existence of a sun without light and heat, and without relation to the nourishment of animal life.

2. The idea of waters without living bodies, is liable to the same exception.

Why should both sea and land abound with the richest varieties of food, and no inhabitants be provided to eat it? If the sublime miracle of the creation can at all be admitted, why make exceptions to Moses, who ascribes inhabitants to the deep on the fifth, and to the land on the sixth day? As the scribe of nature, he certainly here suffers no eclipse on a comparison with many of our modern scribes.

3. The idea elsewhere thrown out, that each more recent order of strata was peopled with a new order of animals, obtrudes the idea of a God deficient in wisdom, who having improved in the art of creation, took away the older and more defective order of things to introduce his new and more perfect work.

4. Man being the last of created beings, and the animals of very many preceding ages having existed happily without him, the creation of so insignificant a being was not essential to complete the grand scale of beings. It is however but justice to add, that the philosophy which we account infidel, has generally spoken of this two-legged animal with honour and respect. His superior formations of arms, countenance, reason, and speech, have become subjects of the highest encomium. Of course, it may be doubted whether our Professor reason well in leaving his own species in so retarded a rank in the scale of the animal formations.

If it be the paucity of human fossils, as is intimated in the Essay, which chiefly prompts the author to reason thus, the Mosaic History will greatly relieve us. It assures us that the nine antediluvian patriarchs did not marry till they were on an average about a hundred and sixteen years of age; whereas the beasts gendered early, and presently covered the earth.—It informs us that the increase of the waters was gradual; and consequently, allowed time for men to save themselves awhile on the summits of mountains and hills, or to embark in canoes and vessels, in which ultimately perishing at sea, they were devoured by fishes; but the beasts had neither precaution nor defence.—It should also be considered, that human bones are small compared with those of the huge animals found petrified in rocks; and that those found in all morasses, have been deposited there by causes more recent than the deluge; I would say, the inundation of Ogyges, and of Deucalion, occasioned by very extensive earthquakes.—Add to these considerations, that human fossils are really found in many situations, and candid enquiry will ask no more. The human skeleton in the British Museum from the limestone rock of Guadaloupe, has been examined by the learned of most nations; and you, Sir, have in your extensive cabinet, part of a femoris from the limestone rock of Gibraltar, which has been pronounced a human fossil. Mr. Whitehurst mentions the perfect human skeleton found in the alum shale near Whitby, in the year 1745, which, though taken up with the greatest care, gradually decomposed on exposure to the air. Another was found in the coal-field of Earl Moira, near Ashby, in Derbyshire, which Mr. Bakewell thinks had fallen in when the ancients worked the mine.—My judgment is, that the ancients in so low a country, had no means of draining the water, and digging 291 feet, and no inclination, the country being full of timber for fuel. I might add other instances from German naturalists; and have no doubt, that when the strata of the torrid zones of Asia come to be examined, the fossil remains of man will be more frequently found in every class of rocks, which we denominate transition.

Professor Werner no where attacks any doctrine of revelation; but he obviously follows Von Oppel, in ascribing a long duration to the earth before the existence of the human species. If the German geologists do not mean hereby tacitly to assert the eternity of the world, an error which Socrates once chased from the schools of Greece, what do they gain by attributing immeasurable periods of existence to it before the epoch of the Genesis, for six thousand, or so many millions of years must be alike small compared with eternity?

In Werner's work, entitled *the New Theory of Veins*, we find the geological situation of metallic ores in the mining district of Freyburg and its vicinity, described with great accuracy: and yet, after the calmest deliberation on the merits of that treatise, I am in doubt whether its accuracies of description, or its eccentricities of inference be the more in number. In more than twenty places, he admits the prevalence of universal waters; that all beds, whether of primitive, or of transition rocks, clays, and sands, proceeded from chemical depositions; that the earth every where abounding with rents and fissures, the mineral veins were formed by deposits of those waters.—Let us hear his sentiments, as in Dr. Anderson's translation. The 28th section is but a short sentence, and comprises the main axiom of his theory. "All true veins were originally, and of necessity, rents, open in their upper part, which have been afterwards filled up from above."

In section 30th he says, "The same precipitations, which in the humid way formed the strata or beds of rocks, and the minerals contained in those rocks, furnished and produced the substance of veins."

Section 35th, "Veins are of two classes: the first consists of lead glance, iron, copper, &c.; the second, which always traverse the former, consists of lead glance, radiated pyrites, heavy spar, fluor spar, and guritz. Fragments of the adjoining rock are often found in veins;—water-worn bowlders;—and petrifactions, which prove that they were originally open fissures. These organic bodies must either have existed in these cavities they now occupy, or have been introduced into them in their present petrified state; on either of which suppositions the vein must have existed in an open state. Rock-salt and pit-coal, substances of very recent formation, occur in veins, which prove that they were originally open fissures."

In proof of these very extraordinary assertions, our professor adds, section 44th, "That certain veins are filled by rolled masses or water-worn stones. And section 66th, "When veins are filled with rolled masses, and when they contain petrefactions, it is not possible that they could have gained admission into the veins in any other way than from above."

This is grave talk at Freyburg; and there really is some degree of correctness in these assertions. Metallic ores do now form in rents and fissures; not by matter washed in form above, but by the ascension of the mineral fluid. When old mines are examined, new formations of ores are generally found. These things being conceded, Werner's new theory, I am decidedly of opinion, is founded on an error, capital in its kind; he mistakes the weak and continued operations of nature for her first and grand exertions, both in the primitive and alluvial earth, in the first formation of metallic veins, as will appear by adducing theories which he calls *exploded*, and comparing them with facts I have examined in English mines.

Becker's *Physica Subterranea* appeared in 1669; it was edited with notes by Stahl in 1703. "He ascribes the re-formation of metals and minerals to certain subterraneous vapours, which arising from the bowels of the earth, and penetrating the veins, produce a peculiar change in such stony and earthly matters as occur in their way." To this passage Stahl adds, in a specimen Becherianum at the end of the work, which indicates Becker and himself to have been Christian geologists—"That from the period of the first existence of our globe, considerable fissures had been formed; that these, at the time of the deluge, were filled up with matter of a soft clayey consistence, which afterwards penetrated by vapours, extricated from the interior parts of the earth, possessing the property of converting these into mineral matter." *Werner on Veins, sect.* 10, 11.

Werner next quotes Henckel, father of mineralogical chemistry, and counsellor of mines to the Elector of Saxony. He died in 1744. "Henckel attributes the formation of the contents of veins to a peculiar exhalation produced and engendered by a fermentation, supposed to take place in the interior of rocks. The base of each metal and mineral, he supposes to exist already in the substance of the rock, and that by a peculiar process of nature it is matured and converted into metal. But he does not venture to ascertain the nature of those bases." The last remark raises a favourable opinion of Henckel's judgment. He knew the limits of knowledge, and where to pause between assured facts and mere conjectures.

Werner quotes a passage from Dr. John Gottl. Lehmann, counsellor of mines to the King of Prussia, respecting traverse veins, with their horizontal branches having some resemblance to a tree, and formed from subterraneous exhalations. Having his works before me, I will indulge the liberty of translating two passages from his *Essay on the beds and strata of the earth*, which do greater justice to his opinions as a miner and a geologist. He affirms, that "beds or the massy rocks of primitive mountains, descend to impenetrable depths; that they are never horizontal, but always vertical, or inclined, cutting the summit of the mountains with sharp angles. In them we find metallic ores at a greater depth than in the stratified and superincumbent rocks." *Section* iii.

He says afterwards, "Nature whose energies are incessant, has filled the fissures of rocks with different formations; such as spathose, quartz, hornstone, and the like; and which being proper to receive the germ of metals and minerals, she constitutes these substances as the matrices of her subsequent formations in the metallic and mineral kingdom." In proof of these assertions, he adds, "We find daily instances, on opening old mines which have been long abandoned, that the productions of the mineral kingdom are there formed anew. Thus it is evident that nature has placed in the bosom of those mountains the proper agent to repeat her energies in the production of metals and minerals, and the essential particles of which they are organized. She has also diversified her operations; for the metallic matrices in the primitive or continued mountains, differ widely in structure from those of the stratified." He elsewhere adds, "in the former, the veins are often richer the deeper we descend, till the water, through the insufficiency of engines, obstructs our following them farther, while in the latter, the veins terminate in a sharp wedge, and become extinct." *Sect.* vi. I may here subjoin, that in the fifth section of

Henckel's Pyritologia, the idea, that veins in the masses of primitive mountains grow richer as they go deeper, is more fully asserted.

From these quotations, it is obvious, that the learned philosophers and miners of Saxony are completely at issue as to the theory of veins. Their formation by the ascension of metallic fluids, and their formation by descension of matter from above, can never be reconciled. The calm enquirer must therefore form his own opinion, whether it be possible for the wide and rocky swells in veins to have fallen in through narrow apertures from above, as well as the thin strata of gold and of plantina, or whether the formation of those veins have proceeded from the elective laws of the mineral essence? Perhaps Werner was not sufficiently aware how much he impugned his favourite *new theory*, and favoured the *old theory* of those authors, when he admits in the 33d section, that "sometimes, though rarely, the richness of a vein may be the effect of an elective attraction or affinity of a neighbouring rock. This seems to have taken place at Kongsberg in Norway; the veins there are richer in ores when they traverse particular beds of the mountains which differ much from the others."

This author confesses that he had not travelled beyond the mines of Saxony, except on a visit to Bakewell in Derbyshire. It were to have been wished he had seen the profusion of our iron veins, extending from Wales to Scotland. In the shelf-mines near the chapel, I found the miners getting the coal, and the ore by an overcast, the method of the Romans in working the Anglesey-mines. It was here I discovered the four strata of iron ores in open day light, as in p. 31. a circumstance with which the visitors are seldom favoured. It was here that the theory of the formation of veins by the ascension, and the concentration, or to use the words of this author, "the elective attraction," of the metallic fluid, was forced upon me: and the repeated reading of the *new theory*, has not made the least impression on the convictions which nature then enforced.

Indeed, I am so far from being made a convert to the new theory of veins, that I regard it as fraught with absurdities; and wonder that so many learned men, through I know not what charm of novelty, or prevalence of human frailty, should receive it with so much confidence. I do not wonder that Werner should be mauled with objections; for his theory goes to prove that there were no traverse metallic veins in the primitive earth, until it became exsiccated into fissures, and shook into rents; and until a second prevalence of universal waters had filled these cavities with metallic depositions, water-worn rocks, and clayey matter!

He tells us (sect. 35th) that "in the mining district of Ehrenfriedersdorf, which contains veins of tin and silver glance, the tin veins are always traversed by the silver." It is so in Cornwall with regard to veins of tin which are often traversed by veins of copper. But why has he not told us either here, or in his relative age of the strata, how the same fluid could deposit tin in veins parallel with the strata of rocks and schists, and deposit silver in traverse fissures? The ascription of a different age to each formation is quite irrelevant here. But the subject of traverse or cross veins containing a different ore may be resumed to greater advantage when the great dykes which divide whole mountains with a subsidence of one side, come to be considered.

On the subject of traverse veins, a German writer asks Werner, if metallic veins were once cavities and rents, how bowlders, or water-worn stones could be suspended in the crossing of those veins, till the metallic matter from above had fallen in to support them? Here our Professor is a little embarrassed. His first reply is, " that we should be assured of such facts." In Cornwall, as well as in the lead measures, we are assured of the facts beyond the possibility of a doubt. W. Phillips, Esq. in his excellent geology of England, referred to in the 67th page, has stated that the lodes of tin, as also the veins of lead, sometimes widen to 24 or even to 30 feet; and that in all such instances masses of rocks and clay are embedded in the ores. Allow me to add, on the suspension of stones in the air, that in the dark ages of the church, the chapel of our Lady first built at the holy sepulchre in Jerusalem, was carried by the angels through the air, and rebuilt at Loretta in Italy in the course of a single night; and in these enlightened ages of philosophy, we find stones unaccountably suspended in the subterranean depths. But Werner's second reply is, that these stones may have fallen into the veins at different times. To me, both the new theory, and the old stones, seem to fall at one time.

The objection which stands in the way of the new theory on the impossibility of *transmutation*, or the elective seizure of a stratum by the metallic fluid, Werner reserves to the last. It was the concentration of his artillery in a desperate case to decide the field. But now, when every thing must be won or lost, instead of meeting the charge, he sounds a retreat, to occupy a tenable ground, and defend a foreign proposition which nobody denies. He says (sect. 91) that " the intransmutability of the simple elementary parts of bodies is one of the fundamental and immoveable pillars of chemistry. We no where see even a trace of a transmutation; for when feldspar is changed into porcelain earth, or when iron pyrites become iron orchre, then one mineral is actually changed into another; but the simple elementary particles have not suffered any change in themselves."—We grant all this, and a cloud of like arguments in full; and immediately pursue him with a thousand waggons, loaded with the organic remains of the former world, whose species are both known and unknown, which once really lived, and which now constitute the real metallic ores of every description. We pursue him with a profusion of organic remains of the vegetable kingdom; with oak, bamboo canes, and fir apples, abundantly found in the iron veins, with wood-tin found in the Cornish lodes, substances which once floated on the waters, and could never fall in traverse veins but five, ten, or twenty inches aside.

To a Christian, who loves to trace the perfections of God in the works of nature, and to make revelation the guide of life, it must be revolting in the highest degree to find the German schools, the French academy, and many of the British writers, empoisoning the sources of literature with the hints of atheism. Our larger Encyclopedias, and many of our Travels and Reviews, are tainted with infidelity, or with Socinianism; " the half-way house to deism," as Mr.Wilberforce tritely remarks.

While Humboldt touched at the Canary Islands, accounted by the Phœnicians and the Greeks, the retreats of felicity, he shrewdly remarks, that " the ancients thought happiness to reside at the end of the earth, as we seek for the utmost exquisite enjoyments of the mind in an ideal world beyond the limits of reality."—Vol. i. p. 245. Ah! My friend—but in what ideal world? Is it in the republic of Plato? Why be so ambiguous on a point which involves the last, the best, and tenderest hopes of man? If this author had made the slightest allusion to a God, a Providence, or a future state, it would fairly preclude his modest hint from being taken in an ill sense. It is, however, but justice to remark, that when the frigate in which he sailed arrived on the coast of Terra Ferma, the yellow fever made its appearance, and carried off three of the crew. The first death Humboldt records with great seriousness, the victim being a young man but 19 years of age. The second and the third death he also records with all the decency of phylosophy, and names the abatement of the disease with a becoming satisfaction. Now, I would here ask, whether these fears, and this joy, had not some relation to a future state? If youth fade as the flower, and age drop as the leaf, merely to promote new geological formations, why should we not fall with apathy as the grass? Why should the hero tremble while his horse rushes on the battle as on a grand parade? The fact is, every passion has the most intimate connexion with its proper object: and if those hopes and fears have no relation to a future state, the Author of nature, who cannot lie, must have written a broad deception on the human heart.

The next prominent error of the Wernerian theory is the relative age of the strata which compose the crust of the earth; and the existence of such a crust must remain a doubtful problem. This discovery Werner often resumes and there does not appear the slightest grounds for persons hostile to revelation to form an objection against it. Take a selection of his ideas.

"Veins, considered as rents, have been produced at very different times, and the relative age of each can be easily assigned. Every vein which intersects another, is newer than the one traversed, and is of later formation than all those which it traverses." *Section* 31. The last sentence, when the state of our dykes is considered, will appear to be quite correct.

"Tin appears to me, if not the most ancient, at least one of the oldest metal formations, for I have never found it in floetz rocks, but sometimes in porphyritic rocks."—*Section* 76. It is replied, that all the *peachy* veins of tin in Cornwall occur in chlorite, a species of floetz slate. The wood-tin found near St. Columb, is also in a stratified formation. "The ores of urania and bismuth appear to be of a newer formation. Gold and silver, of a still newer formation, and in some instances very new."—Sir Tobern Bergman affirms, in his Chemical Essays, that "gold is more diffused through the earth, notwithstanding the smallness of its quantity, than any other metal." Consequently if the fable of relative ages were a fact, gold must be of all those ages.

But our author proceeds. "The iron formations are indisputably the most numerous, and of almost every age; yet in attending to their age, we can point out different formations." *Ibidem.* Almost every age! And if rivers of lava in South America have issued from the base of the primitive mountains, the bottom of which lava, according to specimens in my possession, is almost pure iron; if no deep pit was ever sunk without finding it; and if it enter into the composition of all vegetables, it is not *almost*, but indisputably of every class of strata, and of every age.

In the 68th section, Werner, recapitulating his new theory, adds, "We know for certainty, that floetz and primitive mountains have been produced by a series of precipitations and depositions formed in succession; that these took place from water which covered the globe, existing always more or less generally, and containing the different substances which have been produced from them."

"We are also certain that the fossils which constitute the beds and strata of mountains were dissolved in the universal water, (that is, existed in a state of solution) and were precipitated from it. The metals and minerals found in primitive rocks, and in beds of floetz mountains, were also contained in this universal solvent, and formed from it by precipitation."

"We are farther certain, that at different periods, different fossils have been formed from it, at one time earthy, at another metallic minerals, and at a third other fossils. And from their position, one above another, we know how to determine with the utmost precision, which are the oldest, and which are the newest precipitates."

We cannot pass over these very extraordinary dictates without a few remarks; and especially as our lecturer is certain and assured of every thing he says. The strata of the earth's crust are countless in number, yet they were all formed at different periods, and her eternal existence, of course, is understood!—The huge homogeneal masses, as all the Wernerians allow them to be, the floetz or flat rocks; the fossils of every kind, none of which are in the huge mass; the veins of metals, whether they are parallel with the strata, or whether they traverse the' strata, from which short branches proceed, were all formed by precipitations from the universal water!!! These are the phenomena, the prodigies of the new theory!!! But if the water can work as many miracles as we please by the same precipitations, I am of opinion that those schools have been too severe in satire on the ladies of the convent for piously preserving the milk of the Virgin, the wood of the cross, the coals which burnt St. Lawrence, and other relics of reverance, with which harmless miracles were connected. And with regard to the adorable mysteries of the Christian faith, it is in vain that we tell those schools, that they enlarge our views of the Divine perfections, humble the pride of reason, and excite devotion. It is in vain that we say, the mystery of the resurrection has a tendancy to promote corporeal purity: they still ask for a reason, and profess themselves dissatisfied. On our part, it is but a just repartee to add, that many of their own school profess themselves dissatisfied with the new theory.

When D'Arcet was inaugurated into the chemical chair of France in the year 1776, he pronounced a discourse on the geognostic state of the Pyrenees, from a survey of those mountains he had made the preceding year. And though he fully admits the prevalence of the waters; yet he withholds his sanction from the new theory of an earth formed "through a succession of periods," by chemical precipitates. I will translate a few of his ideas.—"Whatever may have been the first origin of these mountains," he says, "it is assuredly correct to state, that the disposition of the rocks, the order, regularity, and parallelism of which they are formed; the extraneous substances they contain indicate in a manner not to be doubted, the soft and fluid state in which their pristine mass existed anterior to their formation. But shall we say that the whole chain of the Pyrenees has derived its birth from the bosom of the sea? The question is difficult to resolve. While it facilitates on the one hand, the elucidation of many phenomena, it obviously embarrasses on the other, with difficulties still greater in their kind. How horizontal beds might be formed at the bottom of the sea, is easy to imagine; but how could a tranquil fluid produce a symmetrical order of beds, inclined in every direction, sometimes to the north, and the south; and sometimes to the east, and the west; and frequently dipping on the east in a vertical position? Such, however, is the real state in which the strata occur in these mountains, and often in a very limited space of ground. How can we (on the theory of precipitations) explain the formations of granite, whose blocks and masses basset out at every elevation from the visible base in the plain to the highest summit? We have equal difficulty in accounting for the rocks of marble, which are formed in the centre of the chain; rocks which rise perpendicularly for some hundreds of toises? What then shall we say, not of rocks, but rather of whole mountains, where the marmorous formations ascend to the summit, and invariably separated from other rocks by (brazier) rubble, or schistus, and different sorts of gravel; such as those above the valley of Aspa, and on Mount Athas, whose side exhibits a terrific (chaussee) causeway or staircase for two miles and a half, rock piled on rock, from the rivulet to the forest of Issau?"—*Page* 37, 38.

While this learned chemist stood on different summits of the Pyrenees, and where his eye could command a prospect of hills and vallies beneath his feet, an idea struck him which very much relieves geology, with regard to the formation of ravines; a subject no where relieved by the theory of the prevalence of universal water, through immeasurable periods. It was, "that all those ravines had been formed by powerful currents, descending from the highest summits of those mountains." The island of Otaheite contains an almost inaccessible rock of ten or twelve miles in extent. The missionaries, in a map sent to this country, describe seventeen ravines descending from it in a stellated manner. The same idea, that powerful currents had formed the glens and ravines of Scotland, struck Mr. Williams, a surveyor of mines, when he stood on Mount Bineve, contemplating the structure of the country. Having embraced Whiston's notion of "a comet cutting the plain of the ecliptic in its descent towards its perihelion, on the first day of the deluge, passing before the body of our earth, he attributes the formation of the strata and the vallies at once to the theory of the tides. *Mineral Kingdom*, vol. ii. p. 314. It has been stated, page 23, that the deluge of Noah could not have been occasioned by a comet, the strata of the alluvial earth being far more numerous than the tides which a comet could influence while passing before the earth; yet the theory of the tides is the only resource to emancipate geology groaning under the load of German precipitates.

In this way, nature seems uniform in her refutation of the new theories. Her massy granite, so diversified in colour, and in the magnitude of its crystals. Her varieties of huge porphyries, with spots of every colour, with every other genus, species, and variety of primitive, and of transition rock, apparently ask with a thousand voices the question of D'Arcet. How could a tranquil fluid, moved only, as Werner admits, by gentle currents, make deposits so diversified from the hugest blocks to the thinest slate, form strata of every colour and figure; strata which so intimately alternate with other strata as to render their relative ages difficult to demonstrate?—If the primitive rocks and schisti of the Pyrenees obtruded these doubts on the learned chemist, the transition rocks of the Derbyshire mountain limestone obtrude equal doubts of their "having been formed by the precipitates of the universal water." I beg leave to select this district, because latent nature here exposes her bosom in a very remarkable way, and because it has been surveyed by many learned geologists.

The beds are nine in number, extending from Castleton southward 25 miles, and from Mam Tor on the west, to Sheffield on the east. Four of these are limestone, separated from each other by three beds of toadstone. The superincumbent beds are first shale, and then sandstone. The average of the dip is from 30 to 40 degrees; and all the lower beds descend to depths unascertained. The thickness of the lowest bed of limestone is not known; but the toadstone above it has been cut through at the depth of 70 feet. The second limestone, has, in one place, been found to be 200, and its superincumbent toadstone 75 feet thick. The third limestone is averaged at 140 feet, and the toadstone above it at 50 feet. The fourth or uppermost limestone stratum is generally given at 150 feet. The above measurements must, however, be understood as applying to certain places; for the numerous pits sunk through the toadstone on Bonsall Moor, and in the circular extent of 1500 yards, demonstrate the stratum to exhibit a very hilly figure, if its landscape were laid open; and this deduction must generally be made from the mathematical parallels in the plates of Whitehurst and others.

Respecting the four beds of limestone, learned men are of one opinion, that they are all stratified. Consequently, each bed is composed of thinner strata, which vary much in colour and in structure. Some of them are so dark as to be quarried for black marble tablets. Others are of a dull white, increasing their tints to a yellow, and discover the wavings of mineral acids. De la Pryme is of opinion that the Derbyshire people were ignorant of the marmorous treasures contained in their hills. And it ought not to escape notice, that the above four beds are subdivided farther by thin beds of clay, of chert, and thicker beds of swinestone.

The chert occupies a position of strata in some of the limestone beds corresponding with the flint in the chalk. But the colour of the flint, from the uniform whiteness of the chalk, does not vary as the chert, which is always influenced in its colour and figure by the bed in which it is formed, sporting its shades from white to brown and black; in the upper bed, the chert is sometimes so abundant as to obstruct the rock from being burnt for lime; and it is less portuberant than the nodules of flint.

The three beds of toadstone are less known than the limestone; but they are penetrated by pits to come at the galena ores which traverse the limestone, and branch off in veins parallel with the strata. These rocks derive their name from the dark, the black, and variously coloured spots they contain, which have been thought to resemble those on the back of a toad. These, as well as the limestone, wherever they can be seen to advantage, bear unquestionable marks of stratification; and the couches, or smaller beds, are in some places separated by beds of clay. The rocks in general are compact, hard, and often cellular. The darkness of their colour proceeds from iron, whose fluid has been much diffused through the mass; but it often alternates to a dull white. In one place, a vein of galena is known to traverse the whole rock, and short veins of other ores have been found; occurrences which correct the mis-statements of Mr. Whitehurst, who denies the existence of veins in the toadstone.

From the colour and cavities of these rocks, they have been too hastily denominated lava; Werner denominates them amygdaloid. After examining in Portsmouth a thousand specimens of ancient lava, whose bowlders are rolled on shore at St. Helena, and brought as ballast to this country; and after comparing these with recent lava from the Mediterranean, I am fully of opinion, that each has an origin widely distinct from the other. The bowlders appear to have been detached from submarine rivers of lava; to be worn by friction, and to have acquired much weight by the accession of impregnated waters. The beds from which they have been detached, if they could be examined, would be objects of interest to the students of nature. Most of the specimens are highly ferruginous, and alternate in colour from a dull sooty hue, to that of a light iron grey. Some appear to have been detached from the bottom of the lava, and to be as pure as any iron from the blast furnace. They are not in the least porous; but others nearly as pure, are slightly porous, and redder in colour. Some heavy specimens abound with yellow bright specks, which become duller by exposure of the fractures to the air, and these are slightly porous. The lighter specimens have larger pores than the heavy; and others are more than half composed of ashes. The scoria at the top has a black glassy appearance. The toadstone is therefore distinct in its characters from those of the lava. Its cavities are often nearly round, while those of the lava are far more numerous, and have a nearer approach to the figure of the almond. Several parts of the toadstone are highly calcareous, will effervesce in acids, and might be burnt to a weak lime. A few other parts have a columnaral appearance, a circumstance which several Italian writers have noticed also in the lava of Mount Ætna.

Superincumbent on the limestone is the great bed of shale, which in its greatest known thickness is 360 feet. The whole is obviously stratified, and alternates in colour from a dull black, to blue, to grey, and many lighter shades. It contains beds of siliceous freestone, in which the red oxides of iron sport their wavings in beautiful figures and shades. Beds of clay slate often occur, which are not used in roofing houses, because, through a superabundance of clay, and the pyritous fluid, most of the slate decomposes on exposure to the air. Veins of ironstone are frequent, with small veins of galena; and here and there a stratum of coal too thin to be worked. Where balls of pyrites occur, they are scope-formed as those in the chalk. From the base of this great bed the calybeate fountains are known to issue in three places.

Between the shale and the turf lies the bed of sandstone, extending itself from the summit of Mam Tor in a gentle dip towards Sheffield on the east, where it is the underlie of the coal-fields. Its thickness on Darley Moor is 350 feet; but in other places, being worn by diluvian currents, it is very thin. At Dronfield it covers the coal, and averages in thickness about 90 feet; for a very long and undivided stratum is not to be expected in nature. This rock in general is a millstone grit, containing white and clay-coloured quartzose pebbles, granulated quartz, often very coarse, but alternating in other strata to a fine grained freestone. Its varieties are too numerous for detail. In colour, the polished specimens used for gentlemen's houses about Sheffield, are more ferruginous than those of the west of Yorkshire, and the iron sports its wavings in various combinations with oxygen.

That a more correct idea may be entertained of the variations in the thickness of these great beds, and of their stratification, the following statement was procured of a pit now open, two miles from Bakewell.

	Feet.
From the surface, plastic clay, with conglomerates or masses of sandstone and clay	30
Shale, there called black Jack	30
Black mountain limestone	36
Grey coloured limestone	10
Black marmorous limestone	15
A dull white limestone	55
Limestone, with veins of chert	42
Clunch clay, with toadstone rubble	10
The toadstone rock, not there penetrated	00
	228

The upper bed of limestone is 168 feet thick, the sandstone scarcely exists, and the shale is only thirty feet. After this short description of the nine beds, we may proceed with the greater advantage to the grand subject of dispute, whether we can say as Werner, "We know with certainty that the floetz and primitive mountains were produced by a series of precipitations and depositions formed in succession; that these took place from water which covered the globe, existing always more or less generally, and containing the different substances which have been produced from them."

Werner here knew with *certainty*, that both the flat and the primitive rocks were formed by depositions of water existing always; that is according to Cuvier, for thousands of ages before the human species were upon the earth! It sometimes happens that the reader cannot obtain the certainty of the writer. When D'Arcet stood on the Pyrenees, far above the molehills of Freyburg, he could obtain no such certainty. The vertical strata, on whatever side he turned his regards, on those sublime aspects of primitive nature; every where obtruded doubts of the new theory of chemical depositions. He exclaims, "How could a tranquil fluid produce a symmetrical order of beds inclined in every direction?" He avows that the difficulties presented by the new theory were greater than those it removed. Being equally embarrassed on Mam Tor, as he was on the Pyrenees, I beg leave to solicit attention to the opposite theory of the formation of the Derbyshire strata, by the long-continued action of impetuous tides.

1. It may rationally be presumed, that the bold hills south of Sheffield, and those on the north of Castleton, contain a nucleus of primitive rocks, which formed the extremities of a bosom in which the far-rolling sea was disposed, after the first desolations of the deluge, to deposit the warpings of her turbid tides.

2. As each of the nine beds, is compound of couches or beds often very thin,

the body of the whole sea must have moved considerably more than its present very gentle currents, and brought this new warp from some distance; or at least, the black and grey-coloured limestone might be formed by every full and change of the moon.

3. During the absence of each tide, considerable currents would ooze out from all parts of the hills, and from ravines in all alluvial formations, as we see actually to have been the case on the surface. To these the subsidences, the faults, and curvatures may be traced. Mr. Bakewell has given us a plate of a curvature at Wold Park, which equals the cone of a bees' hive. There is neither colliery, nor strata wholly without them. Mr. Williams, to whom we owe this discovery in geology, mentions one at Annandale, as taking an ample sweep, and describing the concave circle of a magnificent arch.—*Min. King.* vol. ii. p. 68.

4. Combating now directly the new theory of the relative age of strata, instead of thousands of ages, I am perfectly satisfied, that nine moons, from tides so tremendous, are a cause adequate to the effect of the formation of those nine beds. The lime, for instance, would instantly proceed to action, shoot its crystals, and form its cement. But the weight of the mass inclined by a dip of 40 degrees, would open chasms. These, when the toadstone matter came to be laid on by the next higher tides, would be filled up with a wedge-shaped rock of toadstone, as is actually the case. The toadstone deposit, or warp, being much slower than the calcareous matter in its formations. Consequently, it would fit itself to the uneven surface of the limestone, and be more even on its surface, and more free from fissures, as is the case on Bonsall Moor, though most of the pits there have not now been wrought of thirty years; yet we know from the exact measurements of the strata given to Mr. Whitehurst, that the under side of the toadstone stratum is astonishingly uneven, while its upper surface is not remarkable for inequalities.

5. Those nine beds were not formed at the distance of immeasurable periods, but rather in the space of nine moons, because the same metallic veins, more or less traverse the whole. In the limestone beds, the galena rises in the fissures, and stretches in branches parallel with the strata of the rock. And, as is the case with those ores in the lead measures, it now and then converts the whole rock into its own formations for a space of many feet, as may be seen in a plate of Mr. Bakewell's, and in Mr. Philip's Introduction to Geology. And sometimes the galena occurs in nodules. The rocks, the matrices, and substance of these wide veins could never have fallen in from above through the very hard and unsocial toadstone: that in Derbyshire would be classed among the reveries of the age. And though galena be scarce in the toadstone, yet one entire traverse vein, and nineteen short ones have been discovered. In the shale also, two veins of galena have been followed by the miners, and others are found too small to pay for working. The iron which expresses reluctance to form its strata in lime and chalk, is seen diffused in the black colour of those rocks, and spots of the toadstone, occupies weak formations in the intervening beds of clay, and exhibits its thicker and nodulous veins in the superincumbent shale and clay. Other ores are likewise diffused through the strata of the district.

In the lead measures of the north of England, the veins are nearly vertical.

"Some," says Mr. Phillips, "are only a few inches wide, while others are several fathoms; the variations in their width is a curious circumstance. In passing down through the beds of shale, they frequently become narrow; but when traversing the limestone they widen considerably; so that a vein which was only two or three feet wide, and very poor while in the shale, suddenly widens on entering the limestone to seventy-two feet, and becomes exceedingly rich in lead ore."—*Geology of England*, Sect. 118. This author adds, that the north and south veins which cross those that are east and west, "are frequently filled up with quartz." Is it now possible? Is it possible on the most plausible expletives, for any attentive student of nature, to believe the Wernerian theory, which repeatedly asserts that all these wide veins of galena, quartz, clay, copper, &c. "fell in from above" through veins in some places not more than two or three inches wide?!! Assuredly, Henckel, Lehmann, Stahl, and others, who contend for the formation of veins by elective attraction, or the concentration of the mineral fluid, have truth, supported by invincible facts, wholly on their side.—*See Bakewell*, Sect. ix.

In farther support of these facts, I quote the well-authenticated statement of White Watson, F. L. S. from his pamphlet which appeared in 1797. "The rake [or traverse] veins generally descend *through* the toadstone; but are seldom found to contain ores when in the toadstone; galena is sometimes found with blende and other minerals; but this circumstance rarely occurs: the veins when in the toadstone, are generally very small, and composed chiefly of calcareous spar, accompanied with asphaltum; when they descend into the limestone, they become thick again, and frequently as rich in ores as before."—Here is another plain testimony, that the *same* vein descends through the whole toadstone, though weak and broken in its metallic formations; and consequently a clear proof that these beds were all formed, not at the distance of thousands of ages, but by the *same* deluge. And it authorizes a farther consequence, that Von Oppel's love child, I would say, this new theory of the relative age of strata; which Werner has adopted and nursed as his own son, and to whom many others have become willing sponsors, is really an alien of spurious birth, who must never be allowed to drive Moses, king of Jeshuron, from his lawful throne.

6. Those nine beds strike me further to be the work of tides during nine moons, rather than immeasurable ages, because the same organic remains are found diffused in a wrecked and ruined state: and a state of violence and agitation can scarcely be conceived to be of long duration. It is allowed by Werner that fossils were dissolved in the universal water; and whatever was his precise meaning, the heat and the acids of the alluvium would indisputably decompose most of the weaker classes of organic bodies. Yet great as the heat must have been in those calcareous and pyritous beds, we find in them a great variety of bivalves, coraloids, or encrinites, entrochi, madrepores, ammonites, and anomiæ; and of the same species which are found in the limestone of Wales, Saxony, and most other calcareous districts.

"At Loberg," says Werner, "in the floetz limestone veins of marl, five or six inches wide occur, containing petrifactions of a quite different species from those found in the mass of the rock." And he quotes Von Schlotheim, who says, that the limestone of Holtzberg contains cornua ammonis, terebratulites, and turbinites."—*Veins*, Sect. 47. The bones of marine animals occur likewise in the limestone. Cuvier states in his Essay, that the remains of a crocodile were found at the bottom of the limestone strata at Honfleur; and Whitehurst says, that a crocodile was found at the top of the upper limestone stratum, near Wirksworth.

My guide at Castleton brought a few bivalves in his hand, which apparently were wholly converted into limestone; but on submitting one to a stroke of the hammer, there was a small bit of dark coloured matter, the apparent remains of the animal, which blazed in the candle. He called it bitumen, as is the local opinion; but whether bitumen or animal, the existence of such small portions of inflammable matter within closed valves, the conclusions are equally favourable to the Mosaic chronology. If it be admitted, as our chemists assert, that all waters hold a portion of silica in a state of solution; and if in 5922 years since the deluge, as calculated in the 4th page, these waters had not perfected the petrifaction, on what ground can an anterior datum be attributed to these fossils?

Extraneous fossils are called by Bergman the medals of nature; and the same species being found in different strata is a demonstration that the age of those beds is contemporaneous. Now, it cannot be denied that the arborescent fern, sometimes found in chert, has the most striking resemblance to the fern abundantly found in the coal-pit shale.

The *encrinites* are described by Mr. Parkinson, a naturalist excelled by none in accuracy of remark and purity of style, as animals of the vegetable class. The species are very numerous; and they have existed in masses. The vertebræ is alternately smaller and larger, to secure a greater facility of motion. The rocks in which they are formed, when fractured transversely, exhibit a stellated and mostly a pentagonal appearance. A few occur of sexagonal and octogonal figure. The posterior, arms, and fingers are so broken and decayed, that litholography cannot exhibit a perfect figure. They are vulgarly denominated fairy stones, and screw-stones.

Madrepores are also plants of five, or often of fifty stellated figures, rising in length as the encrinus or stone lilly. Some of those stars appear as one in each meshe of a net. They occur also in the lead measures, and in the oolite of the south of England.

The *nautilus* he describes as a spiral many-chambered, discoidal univalve, with smooth sides. The chambers separated by transverse septa, which are concave outwards, and perforated by a tube passing through the disk. The last of those chambers he considers as the principal seat of the animal. M. Peron procured a recent one from New Holland.

The *cornua ammonis*, so called from the coiled horn of a ram at each ear of the idol Jupiter Hammon, indicative of power, "is a discoidal spiral multilocular shell," as the nautilus; but the septa and the turns which divide the chambers, in a species sent me from Scarborough, are three or four hundred in number. The perforation may be traced when the fossil is laid open transversely with a saw. They are the snake-stones of the ancients; and in some species the ribs have a supposed resemblance to reptiles. Davila says, in the catalogue of his cabinet, published in 1770, that he had 500, whose spiral coils were from two, three, five, six, eight, to ten in number. He had two found in Normandy, the one thirteen, and another fifteen inches in diameter, with arborizations on the side. In Mr. Kendall's catalogue of minerals found at Scarborough, and its vicinity, one is described of fourteen inches diameter, from a quarry near Malton. M. Voist asserts, that they are almost the only petrifactions which occur in the floetz limestone of Hessia. In the Transactions of the Geological Society, vol. iii. p. 368, Leonard Horner, Esq. describes one he found in the lyas limestone on the Somerset coast, "as 18 inches in diameter, and with the beautiful iridescence of the nacre preserved." Consequently, as these tints of colour are common to the shells of many living animals, it is not likely it could have lain longer than since the deluge of Noah.

Some found in the Dorset oolite rocks, are from 20 to 30 inches in diameter, and 7 in thickness. I examined two of the latter sizes consisting of five coils; with the turns of the shell disposed at the distance of half an inch. Many of these occur in a quarry ten miles from Oxford, which Mr. Parkinson asserts to be half as big as a coach-wheel. He adds, that Rosinus thinks the number of their species cannot be less than 300; and that they are thought, from the power of enlarging and contracting their thin shells, to be natives of the deeper recesses of the ocean.

On the subject of the cornua ammonis, I have, Sir, enlarged the more, that I might enjoy a triumph over certain writers, who seem more disposed to give than to receive the laws of nature. I have five species of the above fossils, one from the oolite, one from the argillite of Yorkshire; one from the chalk flint, and one from the limestone, with a double furrow on the back, no where described by naturalists, presented me by Mr. Lake Allen; as also the ten minute ones, found in the sand-bed under the Hampshire chalk, which you enclosed me under the seal of a letter. Consequently, I am justified in the conclusion, that as various species of these fossils do really occur in the oolite, the freestone, the chalk-flints, the sandstone, the gravel-beds, and enclosed in ovallar nodules in the clunch clay, they most assuredly were laid on, not by chemical deposits through "thousands of ages," but by the six hundred tides of the deluge, consonant to the Mosaic account. Had they lain longer, the iridescence of the nacre could not have remained unimpaired. I am the bolder in these conclusions, because of the many bivalves which occur, with the valves deeply inserted into one another, one of which Mr. Allen presented me from the Bognor limestone; and because of the bowlders of granite, and other primitive rocks which often occur in transition beds of every description.

7. The grand bed of sandstone, so diversified in quality, ought not to be considered as distinct from the numerous beds which extend from Nottingham to the Northern Collieries. It has already been intimated that the finer sands were formed in the loamy surface of the primitive earth. This idea is supported by the chalk rubble, which grows smaller and smaller as it approaches the atmospheric air. These sands, being separated from the clay by the earlier erosions of the deluge, would sink deeper into the sea than the larger pebbles; and consequently, bowlders and pebbles, being more exposed to the currents, would be first driven up by the tide, as is largely the case at the head of the Yorkshire streams. The sands would next be laid on in hills,

and on the declivities and plains. At Woolwich, we have a remarkable illustration of this theory. West of the Dockyard is a mountain of fine sand; then pebbles on an average of half an inch in diameter appear in strata; and then a profusion of pebbles of about two inches in length. To the north of Nottingham, we find these primitive sands often lightly, and sometimes perfectly cemented into rock; but towards Worksop, mostly in loose grains for want of a cementing base.

But how widely soever these primitive sands may be diffused, the general character of these sandstone rocks, is of recent formation, as is demonstrated by the trees, branches, and rivings of timber, with other organic remains, which frequently occur. Small masses of black shorl are also found, as in the oolite and the granite. And it is also to be remarked, that through the whole extent of 200 miles, there is not one hill, which does not differ in family, species, or variety, from the opposite hill. The coarse grit is generally thicker in strata than the fine stone used for the erection of gentlemen's houses. On Heddingley Moor, are thin beds of sandstone nodules, which seldom extend above an acre in length, called *calliards* by our Saxon fathers; that is, of a hard nature. Short beds of the same occur at Stanningley and Farsley, west of Leeds. In the latter place, I found a piece of fir timber, possessing all the qualities of the rock. Marine fossils are scarce; but now and then a shell appears, and minute shells in some places are numerous. Consequently, the whole sandstone district is of recent formation, and among the last deposits of the deluge. This is apparent from the colour which always varies from red to yellow, according to the clay in which the rock is formed; from the ironstone connected with those rocks, which is a formation still more recent; from the numerous and various beds of coal, which is demonstration that the nine Derbyshire and other strata are the work of one long-continued deluge; and from the breaks and desolations of the sandstone, and other strata connected with it.

8. It may farther be noticed, that the four limestone beds, as also the beds in Wales and Scotland, bear a striking proportion in thickness to the beds of chalk in the south; and consequently, the same tides produced the same effects in laying on at the same time equal quantities of calcareous matter.

9. The deposits of the deluge would be heterogeneous in the highest degree. They would contain earths, land, and marine vegetables, and animal substances of every species. Hence in masses so multifarious, moistened and impregnated with all the virtues of the sea, heat, decomposition, and re-organization, would ensue, and on the largest scale that can be conceived in masses so huge thus put in motion. Mr. Whitehurst asserts in capitals, that no vegetable remains have been found in the Derbyshire limestone. But this is only a word of haste in a traveller. The chert often exhibits the fairest impressions of vegetation; and encrinites and madrepores, a hard bodied species of marine vegetables, occur in abundance in some of the strata, while all the weaker vegetables have been much decomposed.

10. The mysterious but essential fluids of nature, thus liberated by decomposition, whether calcareous, arenaceous, or metallic, would collect their strength by elective attraction, seize the new-formed mass, and sport their formations according to the immutable laws of nature, with regard to every essence.

11. Tides so impetuous, rolling afar, would bring turbid matter from a great distance, and thus give the shades of variety to every strata, and to every hill. I should think an idea so well-supported by every appearance of nature, would induce gentlemen to abandon wholly the visionary idea "of the same tranquil fluid," making depositions inconceivably diversified both in their nature, and in the position of their strata.

12. That these beds, or grand magazines of the alluvial earth, did instantly proceed to chemical action, we are authorized to infer from the speedy cementation of lime; from the crystallizations in our sugar-houses; in our salt and copperas works; and in other processes of nature which cannot be numbered. Kirwan has devoted eight pages of his essay to the speedy cementation of rocks. He cites De Sassure's account of the sea-sands blown into the grit-quarry near Messina, which presently become as hard as the rock itself. And at Chatelaillon, he adds, the sea throws up a mud containing shells, which in a few days becomes an indurated limestone. Stone dust of any kind, if mixed with the oxides of iron, presently cements, and becomes a solid rock. The Royal Cornish Geological Society have given an instance of a rock recently formed at St. Erth on the Hayl. The heat excited by the mixture, would accelerate the process; for, according to Henckel, if forty pounds of the oxides of iron and pyrites be ground in water, and left in a mass, the heat will increase to combustion in a short time. Consequently, the heat would vary considerably in mountains abounding with iron and pyrites. These effects being universal, I cannot forbear to think Vogel, Werner, and Cuvier to blame, greatly to blame, for ascribing a sort of eternity of existence to the formations of the earth, when the phenomena of nature can be illustrated on principles far more rational, and free from all the difficulties in which the eternity of matter confuses all our ideas of the Divine Being. God created the heavens *in*, not *before* the beginning of time; yet the first day or two would naturally be a little lengthened till the earth had acquired an equal velocity in her orbit.

13. It must not escape observation, that while the tides were thus warping on these profuse deposits, and while nature in the warm and prolific mass, was repeating her first formations of crystallization and cements, the subsequent and weaker tides, as the deluge subsided, would desolate many of those tender and yet imperfect rocks, and detach them from the extremities of beds. This, I am of opinion, was the case with all the strata, because our miners in places without number, and at all depths, find conglomerates or somewhat rounded masses of rocks. This idea greatly relieves geology, which hitherto has left those masses unaccounted for. When the venerable De Luc was passing through the north of Germany, he justly remarks, that such detached rocks "appear to have fallen from more elevated summits." We cannot doubt that this was the case with the block of granite at Wilkischen in Bohemia, which lies on the surface above the coal.—*Kirwan's Essay*, p. 344.

This idea of the desolations effectuated by the later tides, assists us in accounting for the formation of vallies, and the easy curves of rivers in a manner much more satisfactory than the theory of their having been worn from eternity by the erosions of the stream. Voigt remarks, that "the rivers of Thuringia, Franconia, and Hessia, have cut through the floetz limestone; through the reddish clay, and the gypsum, down to the various sandstones."

This they would naturally do during the neape or weaker tides of the deluge, because the rocks were then soft, and the waters filled the whole of the vallies. But how can gentle streams, never more than gently swoln with rain, open vallies the most uneven in width, and wash away whole strata of the hardest marmorous limestone ?!!

But whatever may be the mature opinion of scientific men respecting the formation of the Derbyshire beds, I am not sure that the view here given is repugnant to some of Werner's remarks in the unguarded moments of his pen. He observes, that "At Wehrau in Lusatia, the strata is composed of sandstone, limestone, bituminous shale, and iron clay, the effects of a partial flood." And what partial flood could warp on four beds so different in their nature as the sandstone, the limestone, the shale, and the clay? These are precisely the Derbyshire beds: they want but the toadstone, which is a scarce rock. What now does our professor gain by the boast "of having given a theory of the earth unconnected with the Mosaic account?"

Let us now proceed to the consideration of another favourite doctrine of the Wernerian System; but which I regard as a most prominent error; that is, a regular and determinate order in the primitive and secondary strata of rocks which surround the earth. On this subject, the words of a British writer have been given in the 60th page; and our German geognost embellishes his sentiments with a simile, which I should not dislike for being homely, were it but correct: "The primary and secondary rocks occur in a determinate order," he says, "and encircle the globe in different layers like the coats of an onion." If Werner has called the system of Dr. Lehmann a dream, he would unquestionably apply the same epithet to what I have said of the curdled masses of the primitive formations. But had I embraced the novel theory of a determination of the strata, the variations in the classifications of the strata in all the Wernerian writers, could not fail to excite doubts and caveats in my mind.

In the 70th page, the theory of Mr. Catcott is given in detail; and its variations from the theory of Werner, of Professor Thompson, and from the joint theory of Brogniart and Curvier are noticed. Since these, we have a more extended theory given us by the Rev. W. Buckland, B. D. which discovers genius, attention, and study. Avowedly making Werner his basis, he divides the earths into five classes, and ten formations. The formations are, allowing me to give the best abridgement I am able,

1. Alluvium, comprising the diluvian, and post diluvian detritus, of blown sands, and bones of herbivorous animals.

2. The trap formations, of floetz trap, whin dykes, basalt, greywacké, greenstone, &c.

3. Formations above the chalk, or the third gypsum of Werner, comprising upper and lower fresh water beds, London, and plastic clay, limestone, &c.

4. The upper and lower chalk formations, flint, chert, fine micaceous grey sand.

5. Green and iron sand; with the various orders of concretious, ochres, barytes, and fullers' earths, with various clays.

6. The oolite formations, which occur in Portland, Purbeck, Bath, Oxford, Colne, Stamford, and in some parts of Yorkshire.

7. The second sandstone, red rock marl, gypsum, and the salt formations; with the conglomerate masses.

8. Coal, shale, grit; mountain limestone; old red sandstone.

9. Greywacké formations of rock and slate, porphyry, greenstone, and bluish grey limestone.

10. Granitous formations of sienite, porphyry, serpentine, greenstone, clay-slate, quartz rock, marble gneiss, and granite.

Humboldt, (vol. iii. p. 108) lays down the succession of the secondary strata in the following order. "1. Ancient sandstone, lying on transition slate. 2. Alpine limestone. 3. Ancient gypsum. 4. Jura limestone. 5. Sandstone of the secondary formation; *molasse;* [that is, French buhrstone.] 6. Fibros gypsum. 7. Limestone of the third formation. 8. Chalk. 9. Limestone with cerites. 10. Gypsum with bones. 11. Sandstone. 12. Fresh-water formations."—After admitting, that some of these strata are often wanting, he adds a remark from Von Buck, (*Beob.* vol. i. p. 104,) that, "when two formations succeed one another immediately, it often happens, that the strata of one begin to alternate with the strata of the other, till the newest formation appears without being mingled with the subordinate strata."

Now, as a plain man, and a lover of nature, I would wish to know what I am to do with all these theories, which are *full of variations?* And I am by no means singular in making complaint. Dr. Maclure has written a work on the Geology of the United States, in which he says, that the order of rocks in North America *is not the same as in Europe.* Among the deviations, one is, that the granite through very extensive savannahs or plains is there the uppermost formation. Mr. Bakewell also blames Professor Jameson for too strongly adhering to Werner's order of the strata, because "at Hartz in Hanover, the gneiss and mica slate are wanting, and in the mining district of Saxony, the clay slate rests immediately on the granite." *Geol.* p. 118.

Mr. Williams, (vol. ii. p. 86,) makes similar complaint. "In all my preambulations and researches," he says, "I have never been able to trace any particular class of strata for any considerable extent; for two or three hundreds of yards, or two or three hundreds of miles, are both small, compared with the circumference of the earth. I once took it for granted, as many do, that every stratum was a zone; but on more accurate examination both in the Highlands and Lowlands, I corrected my error; and now frequent observation and experience have convinced me, that there is no such thing as a very long stretch of the same strata."

Fresh water formations Humboldt places the last or uppermost. I believe he is correct: but Mr. Buckland, misguided by theories, has placed them in the third range of strata. All these formations, whether of rivers or lakes; whether before or after the deluge; whether prior or subsequent to the inundations of Ogyges and Deucalion, invariably once formed the superincumbant stratum; though now we find the ancient ones often elevated above the action of rivers, and slightly capped with other strata. Southwark is built entirely on an estuary of fresh and salt water formations, for the tides formerly came up higher than at present, as is demonstrated (page 44,) by the stratum below Canterbury. When the sewer was drove through the Maze, I procured ten specimens of clay, containing ochres, wood, shells so friable as not to admit of removal, and vegetable fibres of a fine sky blue which do not lose their colour. The marls in the Isle of Wight, however unaccountable at present, I believe, have been formed in the same way. From the curve which the Stoure describes from Blandford to Christchurch, it seems to have joined the Southampton river, and disembogued at Spithead. And I am farther of opinion that the Island has been raised, probably by the great earthquake which has rent England, and formed our dykes, for the northern strata near Newcastle has been raised and depressed as much as 540 feet.

Humboldt puts fibrose gypsum in the sixth order of the secondary strata; but in Cheshire, the gypsum is often fibrose, and it occurs in the alluvium of the upper surface. But these gentlemen evade the force of argument by creating three orders of gypsum, three orders of sandstone, and three orders of limestone; and my opinion is, that they would give juster copies of nature if they created thirty orders, from a conviction that God has not coated the earth with distinct strata, but mixed the rocks for the greater benefit of society.

Again: in those novel theories of coating the earth with a determinate order of strata "like an onion," granite is always placed the lowest and most inaccessible to man. Here again nature suggests her doubts, whether granite be not as often the uppermost as the lowest of primitive rocks. In our own country, it rises from Dartmoor to Scilly, and generally as the uppermost rock; it is often the same in Scotland. It is uppermost in the Norman Isles, and on the French coast. In the celebrated *chausses* of the Pyrenees, it rises for ten leagues. It is the same in the Alps, in the Andes, and in Norway, as we are unquestionably assured by geological travel. Humboldt found granite at the elevation of 11,000 feet on the Andes, and it rises higher, no doubt, if the cold did not deter men from farther ascent. Nor must it escape remark, that on these primitive ridges, there is a chain of volcanos for 500 miles, and a smaller ridge of craters in their rear. Here the fires sport among calcareous and highly ferruginous rocks, far, very far *below the granite!* As the lightning shivers the ancient oak, and lays its verdant branches prostrate on the ground, so this remark of Humboldt, forced upon him by the tremendous aspect of nature, is a thunder stroke to annihilate the Wernerian order of strata, which places granite in the lowest bed. In proof of the correctness of this traveller, I beg leave to add, that having procured forty specimens of ancient lava, brought as ballast from St. Helena, &c. in washing them, the sensation of slaking lime was so strong that I could not bear to breathe the effluvia.

D'Arcet gives us another proof that granite is not the lowest rock. "Above the town of Luz, on the road to Baregés, is a mountain of marble astonishingly elevated. As we ascend till within thirty toises of the Pic [peak] de Leyrey, we every where find the marble disposed in inclined beds, among those of the schist and the granite which are there *interposed.*" [celles de schist et de granite qui y sont interposées]. Pallas found granite reposing on argillite; and Soulavie found it on primeval limestone, and not piercing through the limestone, as some have imagined, for a gallery was worked through the limestone without meeting with granite. *Helvet. Magaz.* vol. iii. p. 175. *in Kirwan.*

These proofs of the mixed state of all primitive rocks, justify the wisdom and goodness of God in creating this variety, and in prescribing to each the laws of formation. He knew that the granite, the oolite, the siliceous, the arenaceous, and the calcareous rocks, with their schists, would all be beneficial; therefore they more or less occur in all extended countries, and in a bold and diversified state, for the use of man. The hills of Charnwood forest have been geologically examined by Mr. Bakewell, who was qualified for the task. "They contain no organic remains; but are *diversified* in the species of rock. Various kinds of slate occur, hornstone, porphyry, porphyritic greenstone, and sienite." This geologist then adds, "I am inclined to believe that these rocks are all *cotemporaneous*, and were all formed from *one homogeneous mass;* but circumstances attending their formation have disposed the parts to assume various arrangements in different situations." *Introd. to Geol.* p. 289.

I thank this gentleman; I thank him heartily. His views of those formations and mine perfectly coincide. Every one knows that a very slight addition in a chemical process will often astonishingly alter the results The declivities of mountains, and the extended plains are generally so embedded with alluvial depositions, that geologists have not been sufficiently aware how much their knowledge of primitive nature is circumscribed. Hence they have laid down theories from some local appearances, and have published them to the world, while the rich variety of nature laughs at the poverty of their ideas.

I am farther dissatisfied, much dissatisfied with the Wernerian order of strata, because of its *inconsistency.* If there be such a determinate order of strata, and if each stratum is younger than its predecessor, and peopled, according to Cuvier, with a new order of animals and of vegetables, why have we not a new order of metals??? for metals are essential to the vegetable kingdom, and very much characterize the diversity of rocks. The mines of Britain, of Sweden, of Germany, and of Peru, have now been wrought both deep and extensively; lavas have laid open the recesses of nature where miners could not go; and, if we except the ores which have escaped attention, nothing new occurs in the metallic kingdom. We have very many testimonies that metallic ores occur in granite; though it be true, that they mostly prefer formations in the softer earths. In Cornwall, the veins of tin, copper, and other ores, are contiguous to the masses of granite. "The most celebrated mines of Mexico and Peru, are found in the primitive and transition schistus, in trap porphyries, the greywacké, and the Alpine limestone." *Humboldt*, vol. iii. p. 525. This remark will very generally apply to most of the mines in Europe. It must therefore be inferred as a glaring inconsistency of nature, that she should, through "thousands of ages" give us new formations of strata, new formations of vegetables, and animals, and ever satiate us with a dull sameness of metallic ores! It obtrudes the idea of a God impoverished by architecture, and circumscribed in his resources.

The last point of dissatisfaction with the presumed order of strata, is the massy appearance of the primitive, and the oblate appearances of the transition rocks, which those theories do not account for. "Mountains entirely formed of primitive marble, are not commonly stratified, but consist of huge blocks without any regular dip or direction, like granitic mountains."—*Kirwan's Essay*, p. 214. In Bowles's travels in Spain, (p. 149,) we find a block of white marble described as three miles in circumference, and 2000 feet high, without any mixture of other stones, or earths, and with scarcely any fissure."

Bineves, in Scotland, is the highest land in Britain. "The granite of this mountain is all of *one mass*, without any appearance of strata, division or fissure of any consideration; but the summit is regularly stratified with a different rock. The precipice on the north-east side exhibits a magnificent section of the inner structure of this great mountain, in which we distinctly see, where the uniform mass of granite ends, and where the stratified rock begins to ride out above it." *Williams's Min. King.* vol. ii. p. 125.

The diamond rock, thirty miles within land from the Cape of Good Hope, is named in Kirwan's Mineralogy as a huge mass, undivided by fissures, 400 feet high, 2500 broad. But more quotations and proofs need not be adduced: geologists fully admit the difference between the primitive and the transition rocks. They admit also the particular marks on primitive pebbles, bowlders, &c. which are rarely found in the latter class. Our inference is therefore plain and conclusive, that the two classes of rocks had a formation essentially distinct. Consequently the most ancient formations, the middle-aged formations; and the more, and the most recent formations cannot be a continuation. A beginning, a creation, and a deluge, are obvious conclusions, and justly imposed by the appearances of the earth.

Two points being now proved, as far as proof ought to be required, the massy state of primitive rocks, and the formation of the transition class by tides, on what principle can we then account for the primitive masses, so easy and natural as that of the curdling theory? Nature herself apparently favours the idea; for in all granitic ranges, the alternation of colours from grey to green, and grey to red, or to a saffron red, is throughout the whole mass without the least fissure. This cannot have proceeded from depositions, but from a collision of masses in so soft a state as to form a perfect union. It may also be noticed, that between the granitic masses, the veins of quartz formations are generally thicker than in any other rocks. I have seen bowlders of granitic quartz eight inches thick, and Humboldt saw at Wunsiedel, veins of crystals two or three feet in diameter, which traversed the rock. Vol. iii. p. 139, note.

I may therefore close this head of remarks in confidence, notwithstanding its brevity, that two grand points are sufficiently proved,—the creation—and the deluge. To these all partial and subsequent formations may be referred. The dream, therefore, of the most ancient, more ancient, middle age, recent, and more recent formations of the grand strata of nature, I regard as a dream; and a dream so ill supported (not denying its charms of novelty,) as to be no longer entitled to the regards and support of the learned world. In the fissures, the rents, and cavities of the earth, nature still sports her metallic and quartzose formations, and often different crystals occur in succession on the same formations, but when the formations of the great rocks of nature were once completed, they have remained the same through all succeeding ages.

The coalfields have next a claim to be revised. They lie in partial groups of strata in different countries, and no where "coat the earth like an onion." They occur on mountains, on declivities, in plains, and vallies. Hence

Werner; from these four circumstances, places their formation at four distinct periods. This philosopher is partial to the ages of nature; and why should not the families of coal have their ages as well as other families? To conceive them to be cotemporaneous, and laid on by the deluge of Noah, would disturb the harmony of the New Theory.

As to the origin of coal, Lavoiser talks of fixed air; but his chemical experiments on carbon left geology unrelieved.

Gensanne contends that coal is an earth, or stone of the argillaceous genus; and Kirwan maintains, that coal proceeds from the disintegration and decomposition of primitive mountains!!! He never reasoned worse. He admits, however, that " the most prevailing opinion is, that all mineral coal is of vegetable origin, that it arises from the immense forests with which the earth was originally covered, which by various subsequent revolutions were buried under those vast strata of earth which at present cover mineral coal."—*Essays*, p. 317—328.

I did not see Mr. Williams's account of coal till a year after I had published my short Introduction: but am gratified to find that the same studies of nature, not of books, have suggested to him in Wales and Scotland, as they did to me in Staffordshire, identically the same ideas. " The antediluvian timber," he says, " floated on the waters of the deluge, till the strata of the highest mountains were formed; and that during the height of the deluge, and the time in which the greatest part of the strata were forming, the timber was prepared and fitted to be deposited in strata of coal."—*Min. King*. vol. ii. p. 212. He further demonstrates the truth of this theory by the extraction of mineralized tar from coal; and by a demonstration that our coalfields never extend under primitive mountains.

Kirwan attempts to evade the force of the arguments of coal having proceeded from vegetables on the ground, that brown fossil timber occurs, not mineralized. It is replied, that all such magazines have been deposited where there was a deficiency of iron and sulphur; and consequently, the vitriolic acid could not perfectly convert the timber into coal. Of such timber we have many varieties in this kingdom. The five thin beds of brown coal at Bovey Tracey have been described by Dr. Milles; but since his time, a sixth bed has been penetrated to, of perfect coal, incumbent, not on clays as the upper beds, but on a stratum of beach-worn sand. Mr. Phillips describes it in the third edition of his excellent Geology of England, to be sixteen feet thick, and Mr. Bakewell seventeen feet. I have no doubt but the sands liberated the mineralizing powers of nature, which had been obstructed in the upper beds by the superincumbent clays. Both in Scotland and in Ireland small quantities of brown coal occur in different situations: The Rev. Richard Watson examined a block of coal brought to Stockport, one end of which exhibited the perfect fibres of timber, while the other was mineralized to real coal.

On the continent, they have considerable magazines of brown coal, where a species of plastic clay, as at Bovey Tracey, obstructs their perfect formation. In Mr. Parkinson's Organic Remains of a former world, three German writers are quoted, Letter xith, where first " Schoockius describes the fossil wood of Meizlibizen as exceedingly like vegetable wood; but that the fibres are very confused; running straight, oblique, transverse, circular, and indeed in every direction, which is never the case in vegetable wood." Certainly the branches, the roots and trunks of trees laid on by tides would leave the timber to be pressed down by the superincumbent strata in all these directions; and the vitriolic acids in the act of mineralization, would weaken the timber, and cause it to yield to the pressure.

Pillingen, describing the wood-coal, near Altenberg, says, "At a little distance from the surface, is found a substance like decayed wood, capable of ignition, bearing marks resembling those of an annual increase; (or growth as in living wood) and so formed by nature, that water is not more like to water, nor milk to milk, than this mineral wood, thus formed by nature, is to vegetable wood. The fibres of this wood, unlike to vegetable wood, are contorted and twisted in almost every direction; and it is generally found split into rivings. It is very light, except when it contained pyrites, and of a brownish colour." When Pillingen "first saw the long veins of wood, and the knots from which branches appear to have grown, he concluded that this was real wood which had been immersed in water; but changed his opinion when he considered that the quantity was too great for a forest to produce, and when he found no ruins of the deluge scattered in masses among it."—Pillingen here erred, as most others, because he did not advert to the idea, that timber floated must be perfectly washed from all the grosser erosions of the deluge.

"Professor Hollman, of Gottingen, presented a paper to the Royal Society of London, printed in the fifty-first volume of their Transactions, with the title of *Montium quorundam prœaltoram magna ligni copia quasi infarctorum, brevis descripto*. In this paper he states, that near the city of Munden, on the top of one of the loftiest hills, is a stratum of mould, near two feet thick, then a stratum of yellowish clay, two or three feet thick; then another stratum of clay, (whose thickness is not described) of brown colour, strongly impregnated with alum and sulphur: beneath these is so large a quantity of fossil wood, as would almost exceed the belief of any one who had not seen it. The miners call it fossil coal. The Professor at first doubted whether this were really timber; but on seeing one trunk with roots adhering to it, much impregnated with pyrites, he became fully convinced that it was indubitably of vegetable origin. The stratum is about twenty feet thick; it rests on a stratum of stone, a foot or more in thickness. On piercing this, there is a second stratum of fossil coal, supposed to be thirty feet or more in depth, and of a much darker brown colour, verging towards *a black;* and the earth which lies over it is of the same colour for about a foot and a half."

"Professor Hollman also describes a mountain near Altendorff, on the borders of Hessia, celebrated for its salt-works. Its height is about 2500 feet, which is 700 higher than the hill just described, near Munden. Here, under an immense roof of rock, varying from 240 to 450 feet in thickness, is a vein of fossil coal, in most places twelve feet thick, which is worked to supply fuel for the neighbouring salt-works. This fossil coal agreed almost in every respect with *a small vein of bitumen* he had observed in the interior passages, which had been dug in the mass of the fossil wood, in the Munden mountain, possessing, like it, the brightness and hardness of jet. It is a circumstance worthy of particular attention, that the stratum of stone at its interior surface, was so exactly adapted to the upper surface of the stratum of coal, as *to give the idea of a fluid matter* having been poured over the subjacent hard and coherent stratum. In the same manner also did the lower surface of the fossil coal apply to the superior surface of the fossil wood."

There is a complaint, Sir, among mineralogists, as to their ignorance of the origin of bitumen, petroleum, naphtha, maltha, and asphaltum. With deference, I think, the vein of bitumen, observed by the above Professor, offers an easy solution. It had, no doubt, distilled from the timber; and indeed, there is scarcely a thick vein of coal wholly free from such formations; and in some instances, the acrimonious oils have descended to depths where no coal is found; or sometimes occur in lakes, to the great injury of the waters. I have not the least doubt that the asphaltum of Derbyshire has descended from the superior coal formations, as described above by Hollman.

It is now hoped, after the preceding arguments shall have been weighed in their relative bearings, that we shall see no more mysterious theories of the origin of coal; and hear no more complaints, that the granite is unfavourable to the coal formation! M. La Mertheries gives one instance in which the coal on Mount Cenis rests immediately on the granite; and I have no doubt, in a few instances, of its resting on every other class of primitive rocks. In the stratified earth we know for certainty, that whole coalfields repose on white and red sandstone; on clunch and plastic clay; on mountain and magnetian limestone; and there is scarcely a transition rock which does not occur as a stratum superincumbent on coal? The wide coalfields of Carlops, south of Edinburgh, are covered with a limestone. At Etruria, in Staffordshire, a thin bed of limestone is also above the coal. Can further evidence be possibly required that the flotillas, now mineralized to coal, had no connexion with the strata on which they repose, nor the strata by which they are embedded in the earth. The recent tides of Moses have here a decided victory over the infinite ages of recent philosophy.

I would next, Sir, glance at the chasms and dykes which are more or less found in all our great coalfields and mining districts. Attention to these, relieves geology of many important difficulties under which it groans. These dykes occur as wedge-shaped rocks of a different genera from those in which they are formed.

1. In primitive rocks. It was said, (p. 10,) that clays or turbid matter of the water would be profusely deposited on the summits and declivities of the rising hills. Consequently subsidencies without number would take place, and chasms be opened of great extent; and the next tide, bringing matter from a distance, would fill up these chasms, and the deposit would there crystalize into a rock of a different kind. Of the fact, not a doubt can be entertained.

2. The dykes in alluvial or transition rocks, would, in like manner, proceed from subsidencies; and the turbid tides, rapidly rolling from a great distance, would fill up the hiatus or chasm with matter, though apparently homogeneous, as Mr. Bakewell justly observes; yet this slight change of matter would induce a formation of rock in the chasm totally different from that in which it formed. Mr. Williams supports this theory by facts. The limestone of Isla, in Scotland, he states to be transition by its stratifications. "It is about ten miles in extent, and I never saw any rock so full of chasms and fissures. It is altogether a mining field, productive of various species of

galena, often rich in silver. The veins are astonishingly numerous. But to determine whether the veins or the whin-dykes were the more numerous, would, I believe, be difficult. The whin-dykes, which generally rise in ridges, and intersect one another, may be seen at a distance. A whin-dyke, whether in the limestone or the coal measure, was at first a chasm, arising from the drainage and exsiccation of the strata, which was filled up with foreign matter by an overflowing tide; and fissures which now remain open, or only filled with sand, clay, or rubble, seem to have been later chasms formed by the drying of the surface."—*Min. King.* vol. ii. p. 76, 78. In the Transactions of the Geological Society, many dykes in the north of Ireland are described which correspond in character with those of Scotland.

The copies of nature which this experienced miner gives, are real and perfect. He states the dykes of the north of England and of Scotland to be filled with five different sorts of rock, clay, or rubble. The whin-stone rock to be basaltic; but often sandstone; and sometimes limestone occurs in the dykes, as in the tunnel of the Huddersfield canal. If the diversity of colour in metallic ores, and all the sports of figure in their crystals, be considered, there will be no difficulty in the conception, that a very slight change in the turpid waters which filled these dykes, would occasion formations of rocks equally diversified. This miner's statement is far more simple and natural than Werner's notion of universal water; of precipitates without the elevation of mountains; and of the filling up of fissures by the falling in of rocks and clays. There were no rocks while the mass was soft.

3. The next order of dykes to be considered are those which traverse the mountains, and divide a wide extent of country. Of these we know but little; their ranges, number, and extent being, as yet, but imperfectly traced. In Bailey's History of the Palatinate of Durham, the great northern dyke is described as rising at Whitley, in Northumberland, passing under the Tyne at Coley-hill, four miles west of Newcastle, and reaching to Landgate. Its width varies from 20 to 30 feet, and in one place it is known to be 100 feet; and branches in some places proceed from it. The coal on either side of the rock is burnt to the distance of 16 feet, where its chared masses begin to appear. The direction in which it runs is nearly from north-east to south-west; it has completely laid open the country, and in one place the strata once parallel, has sunk 540 feet below the strata on the opposite side.

In addition to the above account, Mr. William Gray, of Lemington, informs me, that the direction of the dyke at Coley-hill is from east to west, and the rock 27 feet wide. In its first descent, it assumes a wedge-shaped figure, then a parallel, and after that, the figure of an inverted wedge. But he scruples, on account of the variations in its shape, to make conjectures of its figures, as it descends to depths unknown. The cap rock of the basaltic mass is 14 feet, and of a gravity considerably less than the rock itself. The 20 inch bed of coal traversed by the rock, is covered with a stratum of iron ore, formed in the schistus, which becomes both harder and richer as it approaches the basalts. The schistus continues to change its characters to the distance of 30 feet from the rock, where it retains its natural qualities, and can be cut into excellent slate pencils. In short, Mr. Gray is decidedly of opinion, that the whole rock has had an igneous origin. He adds, that there are three rents in the rock, extending from the surface to depths which cannot be traced, and that the earth which has fallen in, is become ferruginous in a very high degree.

To the above description of this ingenious miner we may add, that the rock when assayed gives 50 silica; 25 iron; 15 alumine; eight lime; and two magnesia. The fourth part being iron, it has communicated a richness to the iron stratum which it traverses, and converted the contiguous earth into its own qualities. So far our iron mines every where give proof of the formation of ferruginous veins by elective attraction, and not by the falling in from above of the matter of those veins, as the new theory would force us to believe. The crystals in some of the rents, are oblate and continuous, with rhombic faces.

With regard to the igneous origin of this most singular rock, geologists, as yet, are not able to form a satisfactory opinion. On comparing fragments of it with the basalts of the Giant's Causeway, and of Rowley Regis, I have inclined to Kirwan's opinion, that the Irish basalts are not lava, because of the paucity of its vesicules. Yet the small crystals copiously dispersed through the Coley-hill whin-stone, were once cavities; and the analysis of the rock is not dissimilar from many specimens of lava. Besides, the lavas slumbering in their liquid beds, are not porous. Of the fact we may be assured from the manufacture of glass. If equal quantities of fine sand, of potash, and the red oxides of lead, with a very slight flux of arsenic, be put into the pot, the mass becomes full of vesicules in the act of liquefaction; but in thirty-six hours the air escapes, and leaves the glass compact. Hence we may infer, that those of the lava arise from the vaporous exhalations which force the erruptions, and from the exhalations which it does, and must receive in its inundations of the open country. In short, I am utterly at a loss to account for the formation of so great a quantity of iron, except from the idea of lava. The hill of Taberg, and other rocks, certaintly contain equal quantities of iron diffused through the mass, but those rocks alternate with others in a way very dissimilar from that of this deep wedge of whin-stone.

The opinion of Sir George Mackenzie, baronet, is apparently in unison with this idea. " The lava of Mount Hekla," he says, " cannot be distinguished from some varieties of basalt, and that of Snæfell Jokul is of the same character. A great many lavas in Ireland contain olivin and feldspar; and several of them have, in addition to these, a large portion of augit.—*Travels in Iceland*, p. 360.

With regard to the extensive rents of the country, and deep subsidences of one side to inconceivable depths, Mr. Phillips describes the cross veins of the lead measures, which run from north to south, nearly parallel with the great northern dyke, as having subsided about 600 feet! The dyke in the north of Yorkshire describes a curve, but is imperfectly known. Mr. Pryce describes the subsidence of a rent in Cornwall to be 132 feet. And as Werner divides veins into two classes, see page 76 and 80; so the cross veins formed in those rents mostly contain different ores. " Cross gossans, or cross flookans," he says, " run through all veins of opposite directions, without the least interruptions from them, but on the contrary, do apparently disjoint, and dislocate all of them: it seems reasonable to conclude, that the east and west veins were antecedent to cross veins; and that some great event, long after the creation, occasioned these transverse clefts and openings. But how, or when, this should come to pass, we cannot presume to form an adequate idea." *Pryce's Mineralogia Cornubiensis*, p. 101.

These rents; these subsidences; these great dykes so fully discovered in the mining districts of England and Germany, could proceed from no cause but that of earthquakes. The strata of one side of a mountain has thus sunk while the opposite side was probably elevated, as appears to have been the case with the marl bed at Headen Hill, in the Isle of Wight; and the different sorts of metallic ores, and other minerals, have since formed there by the ascension and elective attraction of the fluids. Consequently, Werner's new theory of the "minerals falling into those rents from above," receives here its final blow. The mineral kingdom herself fairly rises up in favour of geologists of the elder school.

The plates of Mr. Whitehurst, if I could rightly estimate the thickness of the strata, describe the subsidence of the whole side of the country at Chatsworth, as little less than 600 feet! Von Oppel, in an Essay on the Working of Mines, mentions strata which have shifted their position through the whole extent of the country, and that the veins thus deranged are again found in the direction of the opposite strata.—*Sect.* 42. This is exactly the case in the neighbourhood of Chatsworth; and in other places. Rents so tremendous, and in countries where the hills are low, cannot be the common effects of subsidences; they must have proceeded from earthquakes, which have happened since the formation of ores in the stratified earth.

How tremendous must have been the effects of those burstings of the earth, and irruptions of fire on the air, in the production of unexampled hurricanes, in the prostration of stately forests, and in driving the seas before it? How dreadful must have been the reflux of those seas in inundations of the low and marshy grounds; in the depositions of timber, and the bodies of herbivorous animals in all bogs and morasses where they fed, as we now every where find to have been the case! These remains are assuredly of later deposition than the deluge of Noah, and high up in our holmes and rivers. To give a detail would exceed the limits of a hundred volumes. As the subject is undisputed, an instance or two may suffice. While digging the foundation of the pier of the Span-bridge at Leeds, in 1817, the head and antlers of a large deer were found; and in a position which, I think, could not be less than 20 feet above the high water mark at Beale Lock. M. de la Pryme says, that Hatfield, and all the adjacent marshes, contain a variety of trees large and small, and exhibit whole forests washed down. One tree he found which measured twelve feet in diameter at the swell of the root, which affords a sure chronometer of the distance between the deluge of Noah, and the hurricane which prostrated the forests, and drove the ocean in swells before it. It apparently blew from the south west, for Mr. Derham remarks, that the trees in Essex lie in a north-east direction, as is mostly the case with those of Bridgewater marshes, and the Yorkshire levels. Geology affords also many proofs, that this country was inhabited prior to the above catastrophe. The discovery of hipping-stones has been named in the 44th page. The body of a woman was dug up in the Isle of Axholm, on the Trent, perfectly tanned, and with antique sandals on her feet. We might swell the catalogue of works of art found in bogs. Likewise the fragments of cinders and pit coal found in the upper sand-beds of Cheshire and Lancashire, contiguous to the marshes, and which greatly embarrassed Whitehurst, seem to have proceeded from these inundations.—*See his Enquiry*, p. 182.

To what other causes but earthquakes and hurricanes can we possibly ascribe the inundation of Ogyges, and afterwards that of Deucalion? These events have been alike credited by the early Pagan, and the Christian writers. Eusebius, in his demonstration of the gospel, (lib. x. cap. x.) following the chronography of Africanus, places the time of Ogyges, as a thousand and twenty years before the first Olympiade, and near the time of the Exodus of the Hebrews. To what other cause but inundation can we ascribe the building of the pyramids of ancient Memphis? They are not only mausoleums, but monuments of terror, having steps, according to the plates in Denon's Travels in Egypt, on the whole of the outside walls.

But I will not enlarge. My sole wish, in taking up this subject, has been to rescue religion and revelation out of the hands of atheism. And on a review of these efforts, I feel a personal satisfaction, notwithstanding their defects, and the narrow limits of human knowledge, in having at length approached the temple *ou gît la verité*, which is the permanent repose of truth. Fraught with this confidence, paying at the same time all respectful deference to the learned, I will venture to congratulate the lover of nature and of the Bible, in being able now to contemplate the Creation in the huge homogenial masses of rocks; and to trace the tremendous effects of the long-continued deluge in the extraneous fossils of transition rocks; and likewise in being now able to account for the superabundant bones of animals, and sometimes works of art, which so abundautly occur in the more recent formations of morasses and bogs.

In a chronological view, I congratulate the Christian geologist with more eclat against theories which state the earth to have "no vestige of any beginning," and to have for "thousands of ages" preceded the human species, the infidel writings being admitted in evidence against their authors, Humboldt affirms, "that mica slate and gneiss, in Peru and in New Granada, immediately touch the volcanic porphyries."— Bory de St. Vincent visited the Isle of France, and says, "that the cone of the volcano is calcareous, and contains madrepores." Our Dr. Gillan, whose faith is not impeached, accompanied Sir George Staunton on the embassy to China, and discovered in the ravines of the Pike of Teneriffe, "regular beds of stratified rock." Why have not those prodigious, but *idle* fires made a greater progress during so many "thousands of ages?" I do therefore again congratulate the Christian geologist in being enabled so to study nature as not to feel the least alarm for nature's scribe; but on the contrary, every where to trace the perfections of that Being, who "hath done whatsoever he pleased in heaven, and in earth, in the seas, and in all deep places."—*Psalm* cxxxv. 6.

Wishing you, Sir, in hoary age, the consolations of philosophy, like the Christian Boëtius; and above all, the pure and perfect comforts of the Christian hope,

I am, your obliged
Humble servant,

March 10, 1819. JOSEPH SUTCLIFFE.

GLOSSARY OF GEOLOGICAL WORDS.

Amorphous, without a determinate form.

Ardesia, roofing slate, of various colours.

Alluvial, rocks, earths, and sands warped on by water.

Argil, plural, argilla, clays, both clunch or rock-like, and plastic or soft clay.

Conglomerate rocks, masses of various sizes lying bare on the earth, or buried at great depths.

Dip of a stratum, is the point of the compass towards which it inclines.

Exhalations, vapours which ascend from various fluids.

Fossil, any thing remarkable dug out of the earth.

Fracture, is either compact, as in broken flint and glass; or earth, as in clods of loam; or foliated, as in fine schists; or conchoidal, as in the cleavage of a rock when it resembles very minute shells.

Galena, lead ore; often called glance because of its shining qualities.

Geognosy, explains the formation and position of the strata of the earth.

Inclination of a rock, is the angle it forms with the horizon, which is determined by the quadrant.

Lamellar, composed of thin scales, as hornstone, shale, &c.

Mica, the thin silvery scales in granite, slate, and other rocks.

Matrix, the rock to which ores adhere.

Nodules, stones of an irregular globular figure, as bowlders, chalkflints, &c.

Oryctognosy, the science which examines rocks and fossils.

Pyrites, sulphur combined with iron, copper, or arsenic, &c. mostly crystallized. It is of the plural number, and requires (as in all the Latin writers) a verb plural.

Specular, smooth, shining, reflecting.

Tabular, approaching the floetz, or flat.

Toise, a French fathom; 2300 make a French league, and 25 French are equivalent to 20 English leagues.

Vesicular, abounding with globular cavities.

I refer the less instructed reader to a little work which has just appeared, entitled, "Familiar Lessons on Mineralogy and Geology," by J. Mawe, M. G. S. &c. &c. 149, Strand, London. I refer him also to Professor Jameson's Mineralogy; a work remarkably happy in description; but his Geognosy, speaking with deference, adheres too closely to the Wernerian system.

Page 101, *after whinstone*, add,

"Another mark of fusion, more distinctive of whin, (basalt) is, that both in veins and in masses, it sometimes includes pieces of sandstone, or of other contiguous strata, completely insulated, and having the appearance of fragments of rocks floating in a fluid sufficiently dense and ponderous to sustain their weight.—*Prof. Playfair's Illustration of the Huttonian Theory*, p. 72.

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